European Commission

JRC SCIENCE AND POLICY REPORT

THE 2015 PREDICT REPORT

An Analysis of ICT R&D in the EU and Beyond

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2015

Report EUR 27510 EN

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JRC97153

EUR 27510 EN

ISBN 978-92-79-52698-5 (PDF)

ISSN 1831-9424 (online)

doi:10.2791/350598

Luxembourg: Publications Office of the European Union, 2015

Abstract
The PREDICT project was designed to help policy makers understand ICT sector dynamics and foster its growth. Since its inception in 2006, PREDICT reports and the accompanying databases have become a unique source of information on the ICT sector and on ICT R&D in the EU and its global competitors. The 2015 report offers a comprehensive and comparable view of the dynamics of value added, employment and R&D in ICT industries, detailed in up to 12 individual activities in 41 countries, from 2006 to 2012, relying on the latest available official statistics delivered by the Member States, Eurostat and the OECD. The Report highlights how the ICT sector's overall weight in the economy in the EU stayed stable at about 4% of GDP, but underwent an important shift in composition towards computer services, as it did in most advanced economies. Meanwhile, ICT sector employment passed from 5.8 to 6.2 million (2.7% of total employment). The report also acknowledges the ICT sector's key role in R&D: its share in total business expenditure in R&D (BERD) is about 16% in the EU, 31% in the USA and 52% in Korea.

Acknowledgements

The authors acknowledge the valuable comments and suggestions made by the editors of this report: Giuditta De Prato and Ibrahim K. Rohman. The authors also thank the Ivie team - Eva Benages, Laura Hernández, Juan Pérez and Juan Carlos Robledo – for their valuable contributions. We also gratefully acknowledge Susana Sabater for thorough checking and editing of the text.

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Executive summary

Introduction

The 2015 PREDICT report provides a detailed descriptive analysis of the state of the Information and Communication Technologies (ICT) sector and its Research and Development (R&D) in the European Union and beyond.

This analysis has been carried out by the *Valencian Institute of Economic Research* (Ivie) and the Information Society Unit of the *Institute for Prospective Technological Studies* (JRC-IPTS) under the *Prospective Insights on R&D in ICT* (PREDICT) project. PREDICT is being run by JRC-IPTS for the Directorate General for Communications Networks, Content and Technology (DG CONNECT) of the European Commission.

Table 1: The ICT sector (2007 OECD definition)

Nace Rev. 2	Description
261-264, 268	**ICT manufacturing industries**
261	Manufacture of electronic components and boards
262	Manufacture of computers and peripheral equipment
263	Manufacture of communication equipment
264	Manufacture of consumer electronics
268	Manufacture of magnetic and optical media
465, 582, 61, 62, 631, 951	**ICT total services**
465	**ICT trade industries**
4651	Wholesale of computers, computer peripheral equipment and software
4652	Wholesale of electronic and telecommunications equipment and parts
5820, 61, 62, 631, 951	**ICT services industries**
5820	Software publishing
61	Telecommunications
62	Computer programming, consultancy and related activities
631	Data processing, hosting and related activities; web portals
951	Repair of computers and communication equipment

This is the eighth in a series of annually-published reports, and it is the fourth web-based edition. Like the previous reports, this one is based on the latest data available from official sources such as the Statistical Office of the European Communities (Eurostat) and the Organisation for Economic Co-operation and Development (OECD). The 2015 PREDICT report covers the period 2006–2012. It therefore includes an analysis of the consequences for the European Union (EU) ICT sector and its R&D of the deep recession that began in early 2008, but had its first most severe downturn in 2009. It also analyses the second recession that started in 2012. This is the fourth year in which the PREDICT analysis has followed the NACE Rev 2 definition of the ICT sector[1]. According to this definition, the ICT sector is composed of the sub-sectors described in Table 1.

The analysis first provides an overview of the importance of the EU ICT sector and its R&D. It then gives detailed information: by ICT manufacturing and service sub-sectors, by EU Member State, and in comparison with other non-EU economies currently taking the lead in the world economy, including both developed and emerging economies.

[1] See: OECD Information Economy–Sector definitions based on the International Standard Industry Classification (ISIC 4) available at http://www.oecd.org/science/scienceandtechnologypolicy/38217340.pdf), Annex 1, pg. 15. More details on methodology are provided in Mas, Robledo and Pérez (2012): *ICT sector definition transition from NACE Rev. 1.1 to NACE Rev. 2: A methodological note*, available at http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=5919.

The report confirms some of the trends observed in previous PREDICT analyses. The main observations made in this year's report are the following:

- The EU ICT sector continued to lose share in total value added from 4.10% in 2006 to 3.99% in 2011 and 2012. The more intense job creation in the ICT sector compared to the whole economy resulted in an increase of the ICT sector share in terms of employment from 2.62% in 2006 to 2.73% in 2011 and 2.76% in 2012. The combination of the movements of both variables (higher reduction in Gross Value Added –VA– than employment in 2006–2009 and slower recovery in 2010–12) translated into a continuous fall in EU ICT sector labour productivity. After a fleeting recovery in 2010, EU ICT labour productivity continued to decline due to a decrease in real ICT VA (-0.43%) coupled with a process of job creation in the ICT sector (+0.97%) in 2012.
- ICT sector Business Enterprise R&D (BERD) Expenditure intensity (ICT sector BERD/ICT sector value added) experienced a slight increase between 2011 (5.51%) and 2012 (5.59%), but not as high as the increase between 2010 (5.31%) and 2011 (5.51%).
- The share of ICT R&D public funding (ICT GBAORD, Government Budget Appropriations or Outlays on R&D) of total GBAORD decreased slightly from 6.71% in 2011 to 6.68% in 2012, but recovered to 6.75% in 2013, the highest share since 2006. ICT GBAORD intensity (defined as ICT GBAORD/GDP –Gross Domestic Product) decreased slightly from 0.049% in 2011 to 0.047% in 2012, but increased to 0.048% in 2013.
- The slow recovery in the EU ICT manufacturing sector in 2011 lost momentum in 2012. In 2011, for the first time since the onset of the crisis, the EU ICT manufacturing sector had positive growth rates in employment (0.28%), BERD (3.60%) and R&D personnel (3.32%), but negative growth rates in labour productivity (-6.17%) and ICT sector value added (-5.91%). However, in 2012 the ICT manufacturing sector again experienced negative growth rates in employment (-3.96%), value added (-11.71%), labour productivity (-8.07%) and BERD (-2.84%). Only R&D personnel increased by 1.27%, although this was lower than the increase in 2011 (3.32%).
- In 2012, the ICT sector in the US, the productivity leader in this sector, increased in terms of VA. In addition, the US accounted for 32.16% of ICT VA, 9.88% of ICT employment and 42.37% of ICT BERD of the 13 economies analysed. Furthermore, differences in ICT productivity between the EU and the US continued to grow: US ICT productivity was twice that of the EU. These differences are also repeated in terms of R&D, where the EU is clearly behind the US and three Asian countries (Korea, Japan and Taiwan) in terms of both BERD intensity (BERD/VA) and ICT BERD intensity (ICT BERD/ICT VA). Among Asian countries, the ICT sector's good performance in China and Korea in 2012 should be noted, both in terms of VA and BERD.

The impact of the crisis on the ICT sector

In 2006 and 2007 before the onset of the crisis, EU ICT sector value added (VA) as a share of GDP was stable, at between 4.10% and 4.09%. In the following four years, it experienced a slight but steady decrease, falling to 4.01% in 2010 and to 3.99% in 2011. In 2012, this value stabilised at close to 4% (3.99%). The opposite trend was seen in ICT sector employment which stood up to the crisis more successfully than total employment. In 2012, it represented 2.76% of total EU employment, a higher share than in 2006 (2.62%) and in 2010 (2.66%). Since 2011, ICT sector employment increased by 0.97%, or 59.41 thousand jobs in absolute terms. The combined movements of VA and employment translated into a continuous fall in ICT sector labour productivity. ICT sector labour productivity was 56.75% higher than labour productivity for the whole sector in 2006. This advantage fell to 44.45% in 2012, as ICT sector VA slowed down. Employment, however, proved to be more resilient.

The ICT sub-sectors with the highest weight in GDP and employment in the EU – *Telecommunications* and *Computer programming*– belong to the ICT service sector. The *Telecommunications* sub-sector experienced a reduction in 2012, in real terms, of value added (-4.03%) together with a major job creation process (1.50%). For this reason its labour productivity decreased (-5.46%).

Overall, the available information indicates that the EU ICT sector suffered a sharp contraction in VA in 2009. It improved slightly in 2010 and 2011, only to fall again in 2012 (-0.43%). In terms of employment, job destruction continued through to 2009 and 2010, although new jobs were created in the last two years (2011 and 2012). ICT sector labour productivity, however, continued to decrease in 2012, remaining lower than in 2006 in both absolute and relative terms.

R&D in the EU ICT sector shows positive signs

The ICT sector is one of the most research-intensive sectors in the EU economy. Thus, the ICT sector is a key contributor to the EU's target to reach 3% of GDP invested in R&D by 2020 (Europe 2020[2]). BERD intensity was 1.32% of GDP in 2012 while ICT sector BERD intensity reached 5.59%. That is, it was 4.23 times higher than the total BERD intensity. Furthermore, this ratio was higher than in 2009 (5.26%), when it reached its minimum. Since then, EU ICT BERD has grown continuously, maintaining a 2.36% average annual growth in real terms, although this growth was slower in 2012 (0.98%) than in 2011 (4.87%) and 2010 (1.12%).

The ICT R&D Public Funding, ICT GBAORD (Government Budget Appropriations or Outlays on R&D), in 2012 was estimated to be 6.68% of total EU public funding of R&D (total GBAORD). This percentage has been increasing steadily since 2008 (6.41%), and more noticeably in 2011 (6.71%). In 2012, EU ICT GBAORD fell 4.69% in real terms compared to 2011, but recovered again in 2013 with a positive growth rate of 1.69%.

The total economy and especially ICT manufacturing sectors have an important role to play within total BERD. While manufacturing represents around 14%–15% of VA and employment for the period 2006–2012, its weight in terms of BERD is much higher at around 66%. A similar –although less pronounced– pattern can be seen in ICT service sectors. Their share in terms of BERD is 9.49% while the corresponding figures for VA and employment are 3.64% and 2.27%, respectively. Thus, ICT sub-sectors –especially manufacturing– absorb a much higher proportion of BERD than their weight in the economy would suggest.

The two ICT sub-sectors with the highest BERD share of total BERD in 2012 are *Computer programming* (5.96% of total BERD), which belongs to the ICT service sector, and *Manufacturing of communication equipment* (3.56% of BERD), which belongs to ICT manufacturing. Of the selected non-ICT manufacturing sectors[3] with close relations to ICT and/or R&D, *Manufacture of motor vehicles, trailers and semi-trailers* (14.71%), and *Manufacture of machinery and equipment* (10.89%) have the highest shares in total BERD.

The EU ICT sector R&D personnel and researchers have maintained positive growth rates since 2010. In 2012, the number of personnel involved in R&D activities in the EU ICT sector grew by over 4% compared to 2011, and with greater force in the case of researchers (6.73%). Thus in 2012, 31,545 more people (in full-time equivalent) were carrying out R&D activities in the ICT sector than

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2 http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/targets/index_en.htm.

3 The selected non-ICT manufacturing sectors are: *Manufacture of chemicals and chemical products; Manufacture of pharmaceuticals, medicinal chemical and botanical products; Manufacture of machinery and equipment; Manufacture of motor vehicles, trailers and semi-trailers* and *Manufacture of other transport equipment.*

in 2009, of whom 77% were researchers. This rise in EU ICT R&D personnel was driven by the ICT service sector, which saw its personnel increase from 161.6 thousand people in 2009 to 192.7 thousand in 2012. On the other hand the number of R&D personnel in the ICT manufacturing sector remained constant at around 82 thousand people in the same period.

The importance of EU ICT services sector

The first years of the crisis hit the EU's ICT manufacturing sector more severely than its services sector. The ICT manufacturing sector share of total ICT sector VA fell from 12.18% in 2006 to 8.56% in 2009. In 2010 it experienced a recovery due to stronger ICT manufacturing VA growth in comparison to ICT services or the whole economy, reaching 9.36%. Since then ICT manufacturing has fallen in real terms: -5.91% in 2011 and -11.71% in 2012, with ICT manufacturing's share of total ICT VA dropping to 7.73% in 2012. ICT manufacturing's employment share dropped 4.04 percentage points from 17.67% in 2006 to 12.97% in 2012. Since 2008, the ICT manufacturing sector continuously lost jobs, except for 2011, and employment in ICT manufacturing fell by almost 4% in 2012. BERD in the EU ICT manufacturing sector recovered slightly between 2009 and 2011, but had significantly negative growth rates again in 2012 (-2.90%).

This weakness in the different variables of the EU ICT manufacturing sector contrasts with the strong performance of the ICT services sector in 2011 and 2012. The EU ICT services sector generated more value added in these two years (growth of 1.84% in 2011 and 0.59% in 2012), created more jobs (3.29% and 1.75%), invested more in R&D (5.79% and 3.86%) and had more R&D personnel growth in 2012 (5.86%). These figures confirm the importance of the services sector in the development of the ICT sector in the EU.

The EU ICT sector is concentrated in the largest Member States

In 2012, ICT sector value added was highly concentrated in the five largest EU countries: the United Kingdom (UK) (18.86%), Germany (16.99%), France (15.36%), Italy (11.03%) and Spain (7.04%). These five countries together generated 69.27% of total EU ICT sector VA, and 64.82% of total ICT sector employment.

The picture for ICT sector BERD at the national level is rather different from that of employment or VA. Germany had the highest share (23.64%) of total ICT sector BERD, followed by France (17.82%), the UK (12.45%), Finland (7.63%) and Sweden (7.43%). The differences between VA and BERD shares originate mainly in a country's sectoral specialisation in manufacturing and services: the higher its share of manufacturing, the higher its share in terms of BERD, and also in terms of R&D personnel. This is the case of Finland, whose share of ICT sector VA was 1.25%, compared with 7.63% for ICT sector BERD. But it is not the case for countries that host the production of ICT goods –such as Hungary or Ireland– since in these cases R&D is usually carried out in the home country or in the large neighbouring countries[4]. In 2012, Finland had the highest BERD intensity in the ICT sector, followed by the other two Nordic countries, Sweden and Denmark. Finland also had the highest share of ICT sector R&D personnel of the total ICT sector employment. Finland, together with Sweden, had the highest share of ICT manufacturing personnel (more than 60% of its ICT R&D personnel). However, despite this the ICT sector in Finland has suffered a severe downturn overall. Here, ICT sector VA share in GDP decreased from 4.40% to 3.37% between 2011 and 2012, ICT sector employment share fell from 4.20% to 4.14% and ICT sector labour productivity was the second lowest in the EU due to the weak performance of labour productivity associated with a sharp drop in value added, sharper than in employment. ICT sector BERD share of total BERD also fell by 7.91 percentage points. Finally, Sweden, Finland and Denmark also present the highest share

[4] See *Internationalisation of business investments in R&D*, Innovation Union Competitiveness Papers, Issue 2013/1. European Commission. 2013.

of public funding of ICT R&D (ICT GBAORD) in GDP of all the EU Member States. Thus, the Nordic countries, especially Finland and Sweden, have a weight in ICT sector R&D that goes well beyond their economic size.

US leadership continues to be challenged by the Asian countries but not by the EU

In 2012, the US held onto and improved its lead in the ICT sector in terms of size (it accounted for 32.16% of ICT VA of the 13 economies analysed[5] and 42.37% of ICT BERD) and labour productivity (twice that of the EU and Japan). Of the 13 economies analysed, the US experienced the largest increase in the ICT sector VA share of GDP in 2012, followed by India and Korea. It is the leading country in ICT sector labour productivity, both in ICT manufacture and services sectors. Norway takes the second place –due to its prominent position in ICT services, particularly in *Telecommunications*– followed by Australia. While these three countries experienced ICT sector labour productivity gains, the EU only maintained its productivity levels in the ICT sector between 2011 and 2012. Furthermore, EU ICT sector labour productivity fell behind that of the US, Norway, Australia, Switzerland and Canada, but remained ahead of Taiwan, Japan and Korea. However, ICT labour productivity in these latter countries increased between 2011 and 2012.

Korea and China were the countries with the largest market share increases in 2012 in terms of BERD (more than one percentage point in each country), followed by the US (0.57 percentage points). By contrast, the EU and Japan lost weight in ICT sector BERD between 2011 and 2012. The EU total BERD intensity increased slightly reaching 1.32% in 2012, in contrast to Korea (3.40% in the same year), China (1.51%) and Taiwan (2.27%). BERD intensity for the US and Japan decreased slightly in this period, falling to 1.93% and 2.56% respectively.

In terms of total R&D public funding (GBAORD) as a share of GDP, the differences between countries are not very significant according to available data. However the gap in terms of ICT R&D public funding (ICT GBAORD) is more marked. In this case, the share of ICT R&D public funding in Japan (9.14%) and the US (8.04%) was higher than the EU (6.68%).

The main lessons to be learnt from the international perspective remain the same as in the 2014 PREDICT report. For example, having a large ICT manufacturing sector –like China, Taiwan and Korea– is an important lever for growth, especially when it is combined with important resources devoted to R&D, both in terms of expenditures and of qualified personnel. The strength of the US, compared to the EU, lies in its high productivity levels, the defence of its ICT manufacturing sector, and high R&D resources committed to improve its competitiveness in the world markets. Some of the trends noted by previous PREDICT reports are confirmed: the loss of weight of ICT sector value added in the EU or lower BERD intensity than in the US or in other emerging economies. However, in the PREDICT 2015 report there were some changes from the previous edition: the increase in EU BERD intensity, the decline of labour productivity in the ICT sector due to the fall in value added in real terms, the importance of ICT services in the development of the ICT sector in Europe, the decrease of ICT GBAORD, and the fall of manufacturing employment in 2011, among others.

5 Section 4 compares the EU's ICT R&D position with the most relevant players in the world economy: the US, Canada, Australia, five Asian countries (Taiwan, Korea, Japan, China and India), three European countries not belonging to the EU (Russia, Norway, Switzerland) and Brazil.

Introduction

The 2015 PREDICT Report: "An Analysis of ICT R&D in the EU and beyond" provides a detailed analysis of the state of Information and Communication Technologies (ICT) Research and Development (R&D) activities in the European Union. This is the eighth edition of a series that is published annually. As in the 2012, 2013 and 2014 editions, the 2015 edition is also published in an online version available at: http://is.jrc.ec.europa.eu/pages/ISG/PREDICT.html

This edition is based on the latest data available from official sources, such as Eurostat and OECD. It covers the years 2006 to 2012[6], a period marked by a deep financial and economic crisis.

This analysis was carried out by the *Valencian Institute of Economic Research* (Ivie) and the Information Society Unit of the *Institute for Prospective Technological Studies* (JRC-IPTS) under the *Prospective Insights on R&D in ICT* (PREDICT) project, a research project analysing R&D in ICT in Europe. PREDICT is being run by JRC-IPTS for the Directorate General for Communications Networks, Content and Technology (DG CONNECT) of the European Commission.

The PREDICT analysis provided here is structured as follows:

- An initial overview of the importance of the EU ICT sector and of its R&D.
- Detailed information by ICT manufacturing and services sub-sectors, by EU Member State, and the EU compared with other twelve leading ICT countries from the five continents.

The data and analyses are provided according to the following categories: size of the ICT sector value added in terms of its share of GDP, ICT sector employment and labour productivity, ICT sector business enterprise expenditure on R&D (ICT sector BERD), Public Funding of ICT R&D (ICT GBAORD) and ICT sector R&D personnel and researchers.

Methodological note

The data and analyses provided here are based on data from National Accounts and R&D statistics. PREDICT analyses follow the Statistical Classification of Economic Activities in the European Community (NACE) Rev 2 definition of the ICT sector[7]. This new definition of the ICT sector was adopted in 2006, and since 2008 all Member States have been required to adopt it when reporting ICT sector data.[8] Data was downloaded between January and April 2015 covering the period up to 2012, except in ICT GBAORD, which covers up to 2013.

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[6] ICT GBAORD is estimated for the years 2006-2013 but the figures shown in this report cover the same period as the other variables up to 2012.

[7] OECD Information Economy–Sector definitions based on the international classification equivalent to European NACE Rev. 2, the International Standard Industry Classification (ISIC 4), Annex 1, p.15, available at: http://www.oecd.org/science/scienceandtechnologypolicy/38217340.pdf. The industry classification used appears in Box 1(Chapter 2).

[8] More details on methodology are provided in Mas, Robledo and Pérez (2012), *ICT sector definition transition from NACE Rev. 1.1 to NACE Rev. 2: A methodological note*, Ivie.

1. Overview of the EU ICT sector and its R&D

This chapter provides an overview of the importance of the EU ICT sector and its R&D by presenting the main indicators for period 2006–2012, offering a general perspective which will be analysed in depth in the following three chapters.

1.1 ICT sector value added

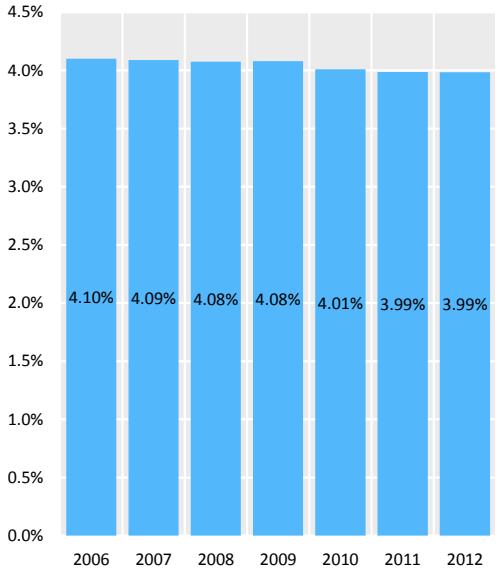
EU ICT sector value added (VA) amounted to 482.36 billion euros in 2006. Six years later it had increased by 34.14 billion euros, reaching a value of 516.50 billion euros, thus growing at a compound annual growth rate of 1.15 in nominal terms and -0.11% in real terms. The EU ICT sector VA represents around 4% of total GDP. Figure 1–1-a shows a slight reduction in this share from 4.10% in 2006 to 3.99% in 2012, but it remained stable between 2011 and 2012. Figure 1–1-b shows a very similar annual growth rate[9] in both variables, especially in the first part of the period. Between 2006 and 2007, ICT sector VA and GDP grew at a rate of 2.96% and 3.20% in real terms, respectively. However, during the first year of recession ICT sector VA growth rate fell to 0.03% and GDP to 0.38%. Both variables experienced a drop (around -4.48%) in 2009, to recover again in 2010 and 2011. The annual growth rate of ICT sector VA accelerated from 0.28% in 2010 to 1.07% in 2011. After two years of growth, both ICT sector value added and GDP returned to negative growth rates in 2012, -0.43% and -0.39% respectively.

ICT sector VA is concentrated in the ICT services sectors as Figure 1–2-a illustrates. ICT manufacturing VA represents around 9.9% of total ICT sector value added throughout the period analysed. However a distinct feature is that it has been losing share since the beginning of the recession. While in 2006 ICT manufacturing VA represented 12.18% of total VA, in 2012 this share had decreased by almost 4.5 percentage points, to 7.73%. This result indicates that ICT manufacturing has suffered more from the downturn of economic activity than ICT services, and it continued losing weight in 2012. ICT manufacturing VA shrank by -12.42% in 2008 and -23.33% in 2009. However, it recovered in 2010 when it grew at a rate of 9.68% but contracted again in 2011 (at a rate of -5.91%) and more markedly in 2012 (-11.71%). Compared to these figures, the pattern of growth in ICT services VA was much more stable, decreasing only by -2.19% at its severest moment in 2009 and growing between 2010 and 2011 at a rate of 1.79%. Even with the second recession in 2012, ICT services still grew (0.65%).

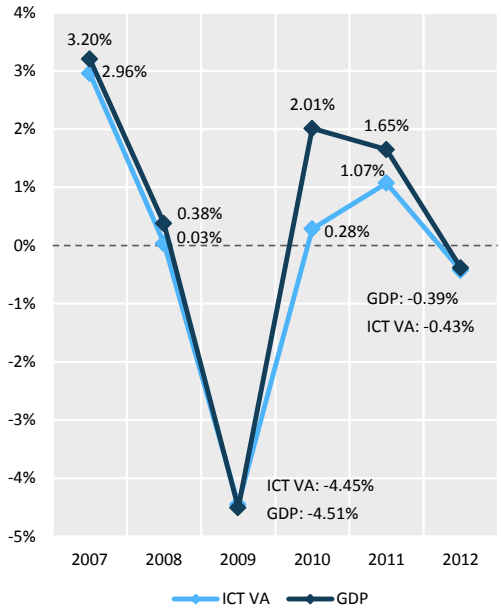
[9] All growth rates are computed in real terms using the implicit GDP deflator (chained volume estimates or fixed-base volume estimates, depending on countries).

Figure 1

a: ICT sector value added share of total value added. European Union (2006–2012)



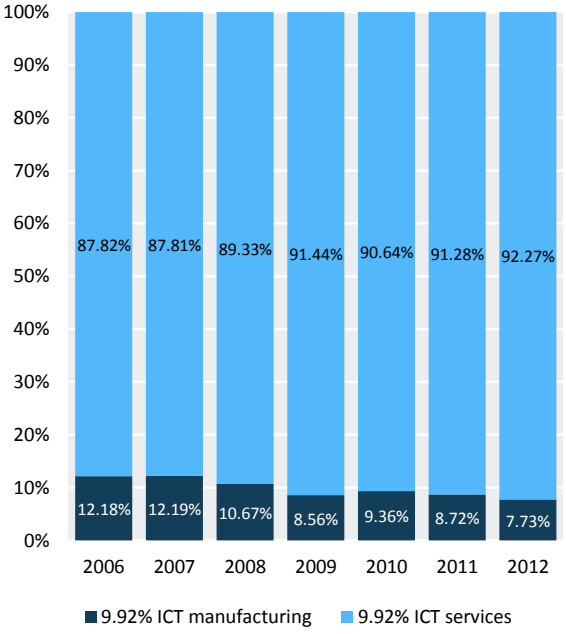
b: ICT sector value added and GDP real annual growth rates. European Union (2006–2012)



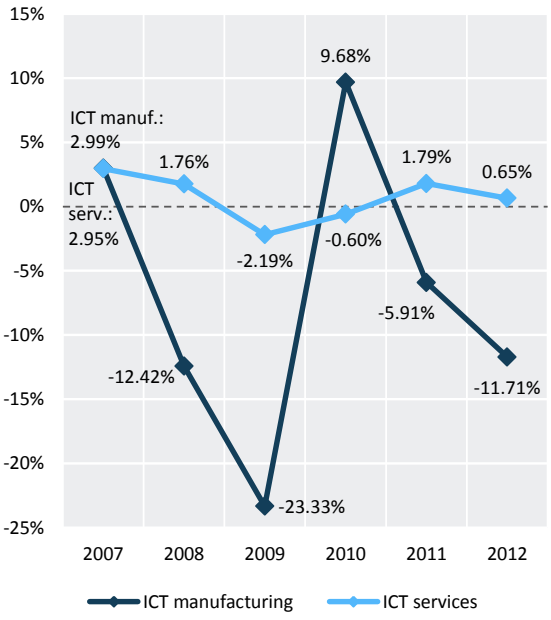
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 2

a: Distribution of ICT sector VA shares for ICT manufacturing and ICT services. European Union (2006–2012)



b: Annual real growth rates of ICT manufacturing and ICT services value added. European Union (2006–2012)

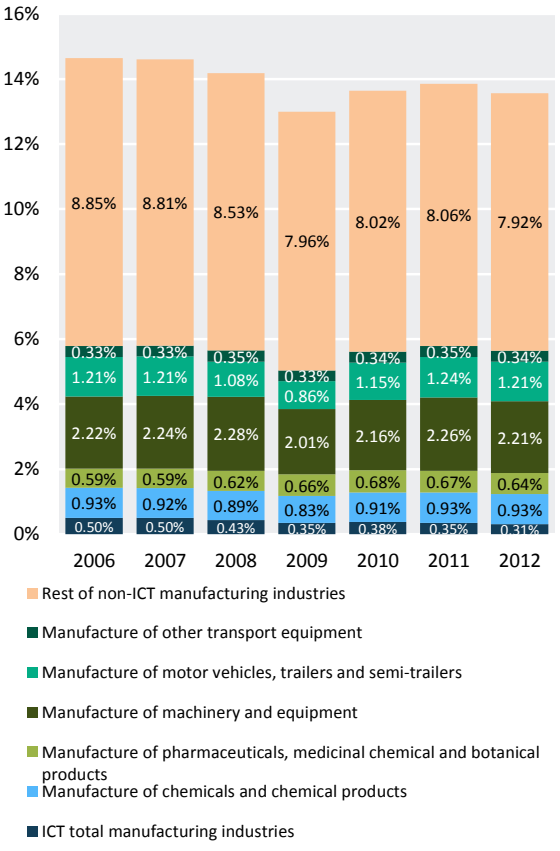


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

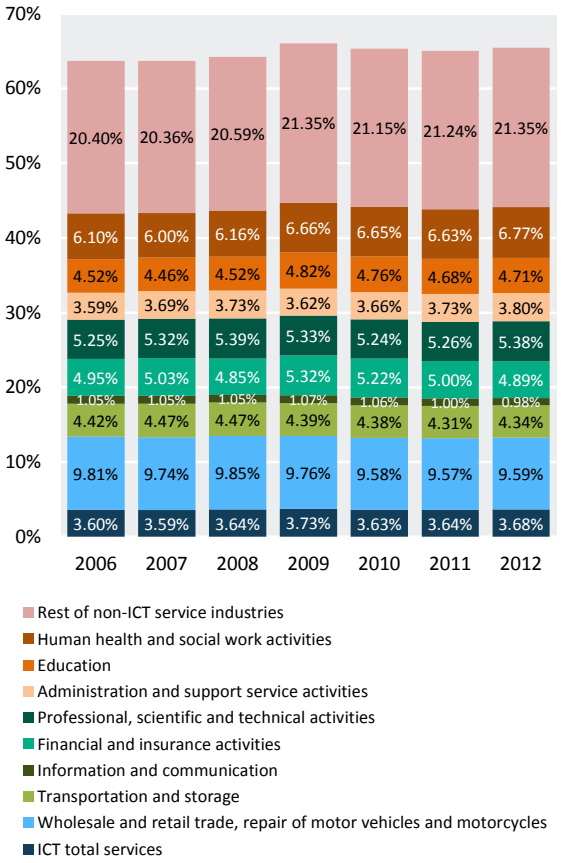
The value added generated by the whole manufacturing sector (including ICT and non-ICT industries) represents around 13%–14% of total GDP in the EU. Figure 3-a shows how this percentage is split among ICT and some selected non-ICT sub-sectors that in some way have a closer relation with ICT and/or R&D. ICT manufacturing sectors represented 0.3%–0.5% of total GDP, continuously losing share in the period. In 2012 they represented only 0.31%. Other sectors with a close link to ICT and/or R&D also have a small share of GDP, with *Manufacture of machinery and equipment* having the highest share (around 2.2%).

Figure 3: ICT sector value added share of GDP and comparison with non-ICT economic activities. European Union (2006–2012)

a) Manufacturing



b) Services



Note: *Agriculture, forestry and fishing; Mining and quarrying; Electricity, gas, steam and air conditioning supply; Water supply, sewerage, waste management and remediation activities;* and *Construction* are not included in either manufacturing or services industries.

Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 3-b provides similar information but related to the services VA share of GDP. Services VA represents around 64%–65% of total GDP in the EU. ICT services sectors accounted for 3.68% of total GDP in 2012. *Wholesale and retail trade, repair of motor vehicles and motorcycles* (9.59%), *Human health and social work activities* (6.77%) and *Professional, scientific and technical activities* (5.38%) are the non-ICT services sectors with the highest shares of GDP. Overall, the information confirms that the EU has a greater intensity of ICT activities in the service sector than in manufacturing, as the ICT services sector represents 5.6% of total services VA whereas ICT manufacturing only accounts for 2.3% of total manufacturing VA. Now the share of VA in total

services VA of the group termed "rest of non-ICT services industries" is lower than that of manufacturing, representing around one third of total service VA share.

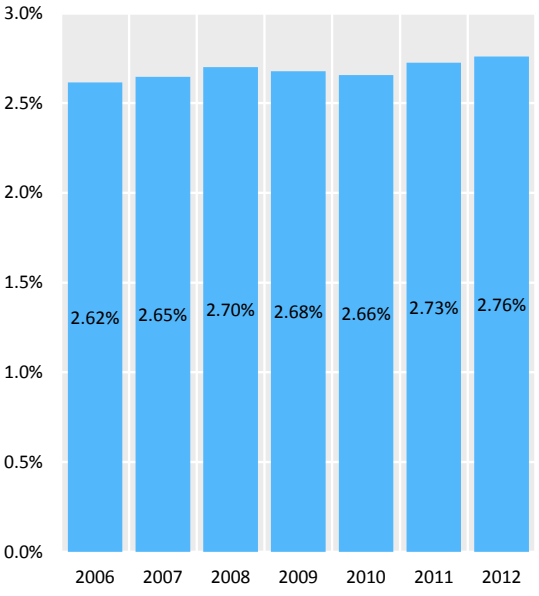
1.2 ICT sector employment and ICT sector labour productivity

1.2.1 ICT sector employment

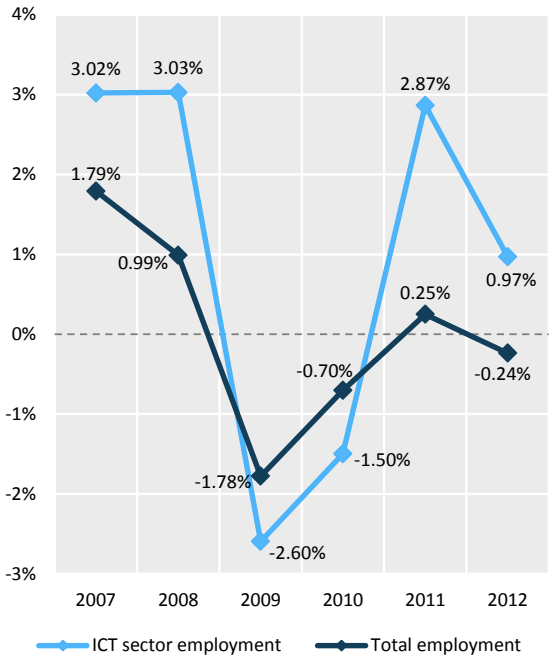
Total ICT sector employment in the EU amounted to 5.84 million people in 2006 and 6.18 million people in 2012, a positive variation of around 337.24 thousand workers. The ICT sector employment share of total EU employment (2.76%) is lower than that of VA. This percentage has also remained fairly stable over the seven years analysed, oscillating very slightly between 2.62% in 2006 and 2.76% in 2012 as indicated in Figure 4-a. In contrast to the case of VA, ICT sector employment share increased during the first years of the recession that started in 2008, falling since this year until 2011, when it increased to 2.73%, a tendency that continued in 2012 when it grew to 2.76%. Figure 4-b illustrates the pattern for the annual rate of growth of ICT sector and total employment in the EU. In 2007 ICT sector employment grew at an annual rate of around 3%, almost doubling total employment growth. ICT sector employment did not suffer the slowdown that ICT sector VA experienced in 2008, the first year of recession, since it continued to grow at an annual rate of 3.03%, tripling total employment growth. By contrast, the fall in the rate of growth of ICT sector employment in the following two years was more severe than for the total economy. In 2011 ICT sector employment reversed this contraction, growing at a rate of 2.87% in contrast to the 0.25% rate of total employment. In 2012 the ICT sector continued to create employment with a positive growth rate of 0.97%, in contrast to the reduction of employment (-0.24%) in the EU aggregated economy.

Figure 4

a: ICT sector employment share of total employment. European Union (2006–2012)



b: ICT sector employment and total employment annual growth rates. European Union (2006–2012)



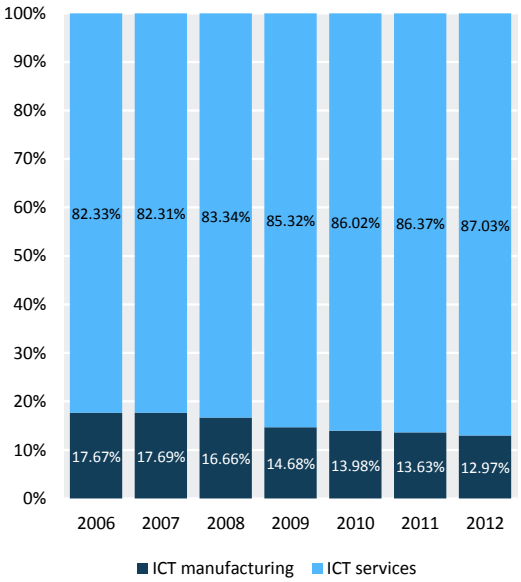
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

The ICT manufacturing employment share of total ICT sector employment is higher than its share in terms of VA. Figure 5-a indicates that –as in the case of VA– this share fell throughout the period from 17.67% in 2006 to 12.97% in 2012. It is interesting to note, in Figure 5-b, that employment in the ICT service sectors did not suffer the adverse effect of the economic crisis (2008–2010) to the same extent as ICT manufacturing employment or total employment. In fact, while manufacturing experienced a drop of -14.20% in 2009, ICT service employment only shrank by -0.28%. In 2011, both ICT manufacturing and ICT services employment began to grow at a positive rate, especially ICT services (3.29%). In 2012 the prospects worsened as compared with 2011. ICT services still generated employment in 2012 at a rate of 1.75%, despite the second recession, whereas employment fell in the ICT manufacturing sector (-3.96%).

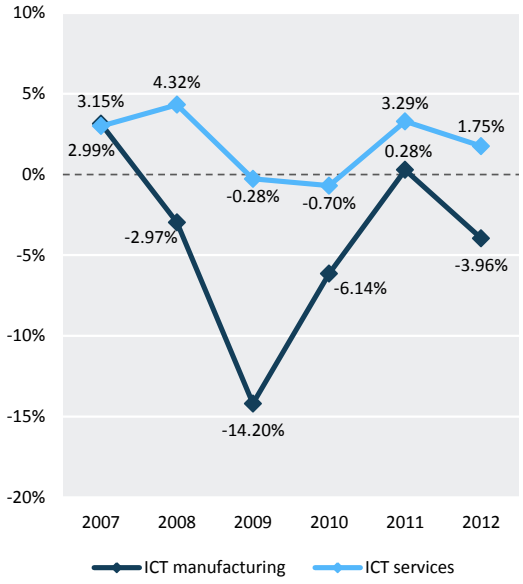
Figure 6-a shows that employment in the EU manufacturing sectors represents around 14%–16% of total employment, a slightly higher share than the 13%–15% for VA (see Figure 3-a). Employment in ICT manufacturing sectors represents around 0.4% of total employment, a percentage similar to that of VA. *Manufacture of machinery and equipment* had the highest share (2.04%) in 2012, as already seen in terms of VA. The non-ICT sub-sectors that are not closely related to ICT and/or R&D ("rest of non-ICT manufacturing industries"[10] in Figure 6-a) represent more than two thirds of total manufacturing employment.

Figure 5

a: Distribution of ICT sector employment shares for ICT manufacturing and ICT services. European Union (2006–2012)



b: Annual growth rates of ICT manufacturing and ICT services employment. European Union (2006–2012)

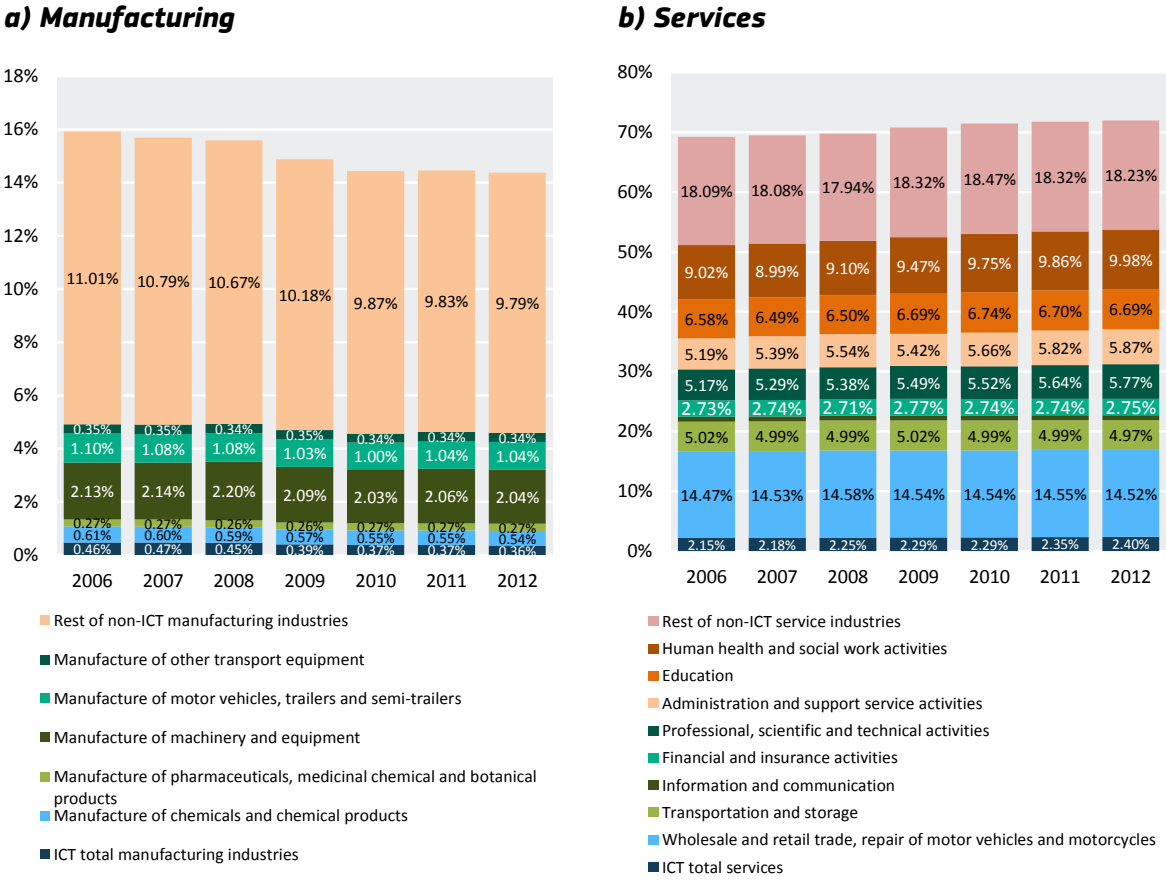


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

[10] Rest of non-ICT manufacturing industries includes: *Manufacture of food products, beverages and tobacco products; Manufacture of wood and paper products, and printing; Manufacture of coke, and refined petroleum products; Manufacture of rubber and plastics products, and other non-metallic mineral products; Manufacture of basic metals and fabricated metal products, except machinery and equipment; Manufacture of instruments and appliances for measuring, testing and navigation; Watches and clocks; Manufacture of irradiation, electro-medical and electrotherapeutic equipment; Manufacture of optical instruments and photographic equipment;* and *Other manufacturing, and repair and installation of machinery and equipment.*

Employment in services sectors represents around 70% of total employment while in the ICT services sectors this figure stands at around 2.3% (Figure 6-b). As before, the sectors with the highest shares are *Wholesale and retail trade, repair or motor vehicles and motorcycles* (14.52%) and *Human health and social work activities* (9.98%). Now, the share of the "rest of non-ICT services industries"[11] group is lower than that of manufacturing, representing around a quarter of total service employment.

Figure 6: ICT sector employment share of total employment and comparison with non-ICT economic activities. European Union (2006–2012)



Note: Agriculture, forestry and fishing; Mining and quarrying; Electricity, gas, steam and air conditioning supply; Water supply, sewerage, waste management and remediation activities; and *Construction* are not included in either manufacturing or services industries.

Source: Eurostat, elaborated by Ivie and JRC-IPTS.

1.2.2 ICT sector labour productivity

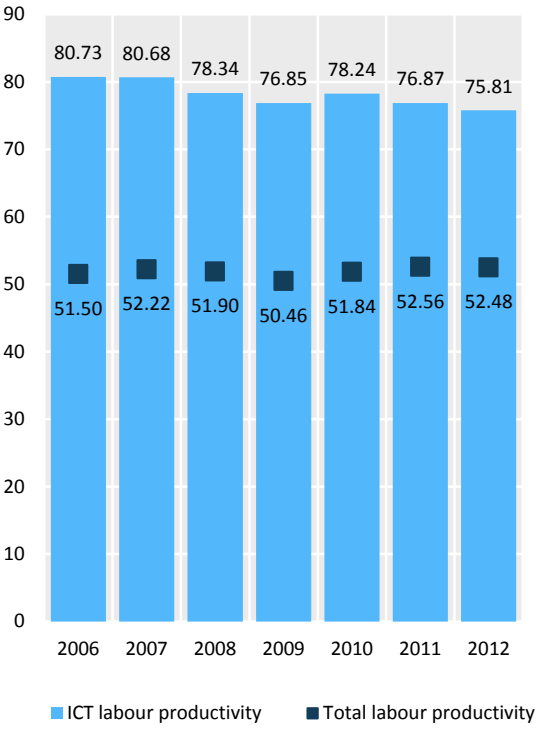
Labour productivity in the ICT sector (ICT sector VA/ICT sector employment) amounted to around 75.8 thousand constant euros per person in 2012, 44.45% higher than total labour productivity (total VA/total employment) (Figure 7-a). Before the onset of the economic crisis, labour productivity in the ICT sector grew at a lower rate than in the total economy. As shown in Figure 7-b, in 2010 both variables had recovered a similar rate, 2.73% for total labour productivity and 1.81% for ICT

[11] This group includes *Accommodation and food service activities; Real estate activities; Public administration and defence; Compulsory social security and other service activities; Activities of households as employers and extraterritorial organisations and bodies (except repair of computers and communication equipment).*

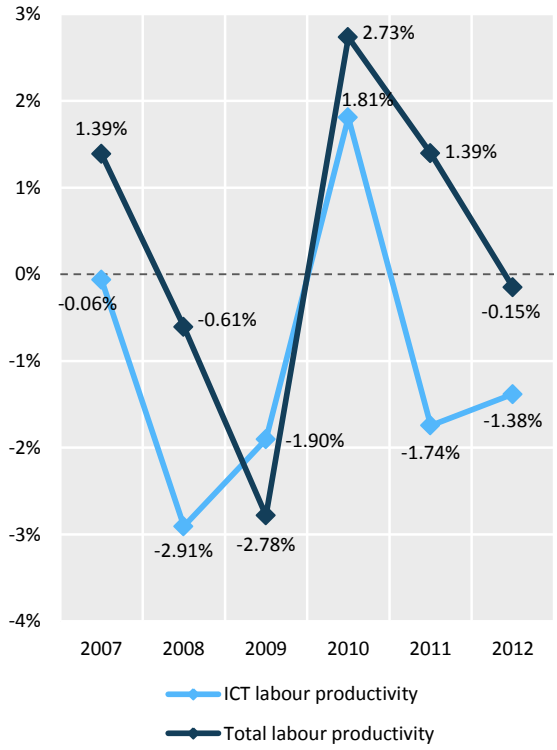
sector labour productivity, due to the recovery of VA growth together with the fall in employment. Both ICT and total labour productivity contracted severely in 2011; this was especially marked in the ICT sector (-1.74%). In 2012 the fall in total labour productivity accelerated while ICT labour productivity slowed down but still presented negative rates of growth (-1.38%).

Figure 7

a: ICT sector and total labour productivity. European Union (thousand constant [base year 2005] EUR per person; 2006–2012)



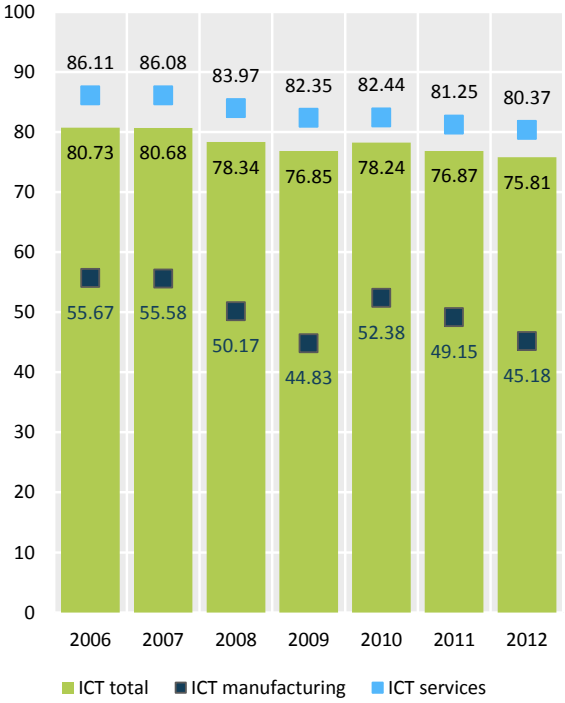
b: ICT sector and total labour productivity annual real growth rates. European Union (2006–2012)



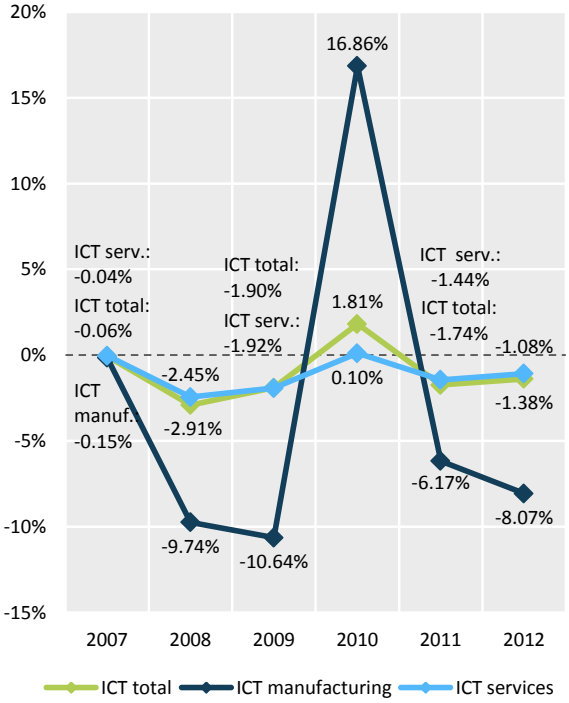
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 8-a shows that labour productivity is 80% higher in the ICT services sector than in manufacturing. In 2012, labour productivity in manufacturing amounted to 45.18 thousand constant euros per person, while in services the corresponding figure was 80% higher at 80.37 thousand constant euros. Figure 8-b reports the time profile for labour productivity growth throughout the period 2006–2012. ICT services sector labour productivity presented a very similar pattern to total ICT sector labour productivity due to its high share in the aggregate. Its growth was almost 0% in 2007, the last year of the expansion period preceding the crisis. In the first two years of recession, 2008 and 2009, ICT sector labour productivity fell; this drop was particularly intense in the ICT manufacturing sector, especially in 2009 when its annual contraction was -10.64%. In 2010 it experienced a notable increase, growing at an annual rate of 16.86%, due to the combination of a manufacturing VA growth of 9.68% (Figure 2-b) and a drop of -6.14% in manufacturing employment (Figure 5-b). In the last two years, however, ICT sector labour productivity underwent a general decrease (-1.74% in 2011 and -1.38% in 2012), which was especially intense in ICT manufacturing. This drop was even more severe in 2012 (-8.07%) than in 2011 (-6.17%). Taken all together, labour productivity in the EU presented a much more cyclical pattern in ICT manufacturing than in ICT services sectors.

Figure 8
a: ICT sector labour productivity. Manufacturing and services. European Union (thousand constant [base year 2005] EUR per person; 2006–2012)



b: ICT sector labour productivity annual real growth rates. Manufacturing and services. European Union (2006–2012)



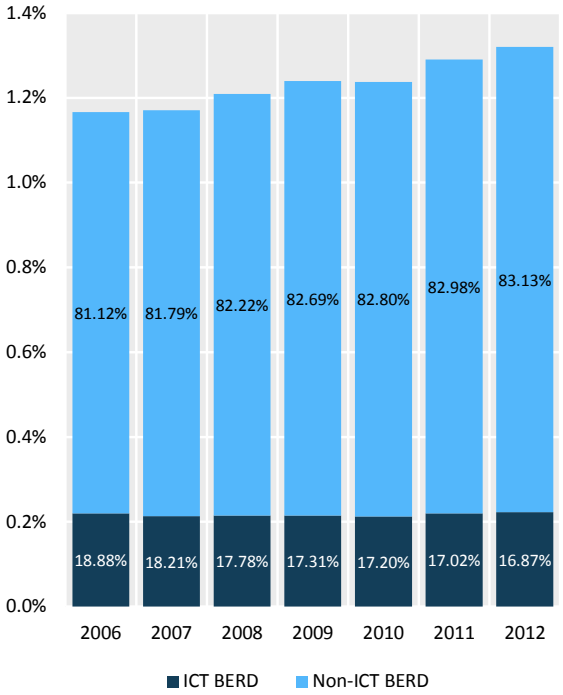
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

1.3 ICT sector business enterprise R&D (BERD) expenditure

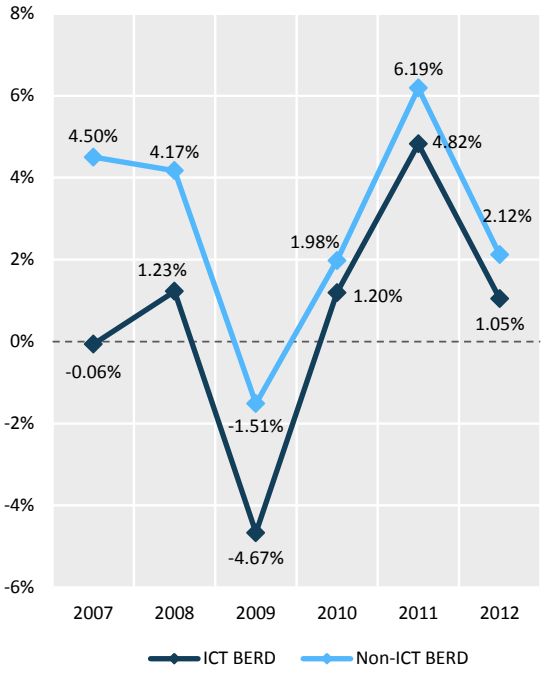
ICT sector BERD amounted to 25.90 billion euros in the EU in 2006. In 2012, it had increased by 2.96 billion euros. The weight of BERD over GDP –or BERD intensity (BERD/GDP)– was between 1.17% in 2006 and 1.32% in 2012, and it also increased in 2012 with respect to 2011. Figure 9-a shows how this percentage was split between ICT and non-ICT sector. While ICT sector VA represented around 4% of total VA, and ICT sector employment around 2.7% of total employment, ICT sector BERD had a higher share of total BERD, around 17.6% on average during the period 2006–2012. However, these last years saw a continuous fall in the ICT sector BERD share from 18.88% in 2006 to 16.87% in 2012. In contrast to the case of total BERD, in the ICT sector this share fell continuously since 2006. ICT sector BERD suffered a more severe contraction in 2009 than total BERD, when ICT sector BERD experienced a -4.64% annual rate of variation while the fall in non-ICT sector BERD was less pronounced at -1.48% (Figure 9-b). After 2010 expenditure on R&D grew continuously, although in 2012 at a slower pace than in the previous years (1.05% in the ICT sector and 2.12% in the rest of sectors).

Figure 9

a: Contribution of ICT and non-ICT sector BERD to total BERD intensity (BERD/GDP). European Union (2006–2012)



b: ICT sector BERD and non-ICT sector BERD annual real growth rates. European Union (2006–2012)

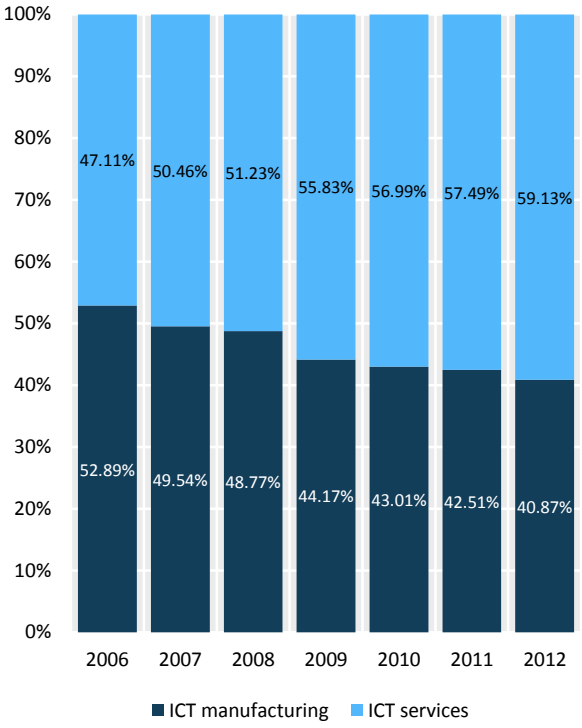


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

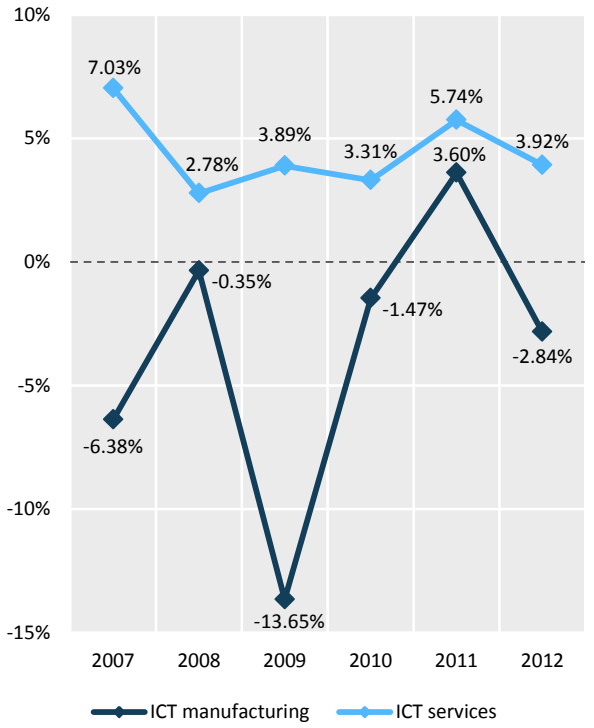
ICT manufacturing has a higher share in terms of ICT sector BERD than ICT sector VA or ICT sector employment. As Figure 10-a shows, ICT sector BERD in manufacturing has a share of total ICT sector BERD of around 46%, but it fell quite sharply in seven years from 52.89% in 2006 to 42.51% in 2011 and to 40.87% in 2012. The reason for this must lie in the continuous decline of ICT manufacturing BERD in absolute terms, as illustrated in Figure 10-b by the negative rates of growth shown throughout the period with the exception of 2011. This pattern contrasts with the trend in ICT services sector BERD, which even in the worst years of the crisis, 2007, 2009 and 2012, presented positive growth rates of 7.03%, 3.89% and 3.92%, respectively. This growth of ICT sector BERD intensity in 2012, the latest year with available data, contrasts with the reduction in ICT manufacturing BERD (-2.84%).

Figure 10

a: ICT manufacturing and ICT services BERD. Share of total ICT sector BERD. European Union (2006–2012)



b: ICT manufacturing and ICT services BERD annual real growth rates. European Union (2006–2012)

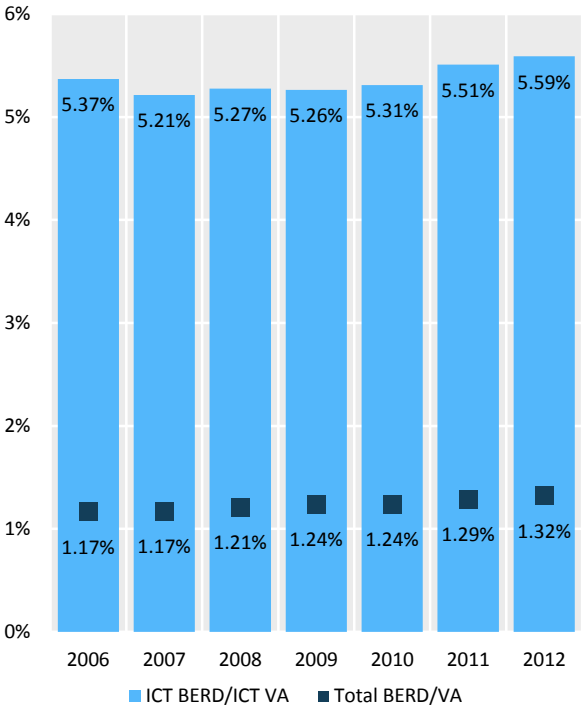


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

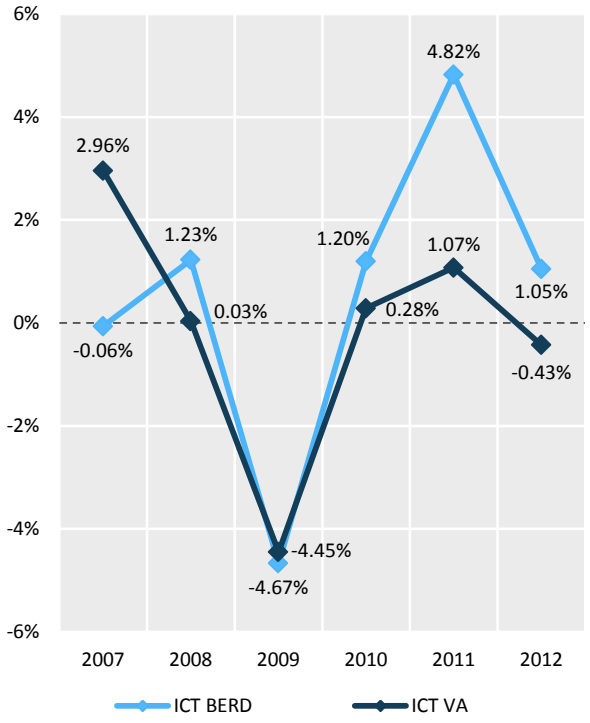
Figure 11-a shows that the ratio of ICT sector BERD to ICT sector VA –termed ICT sector BERD intensity– remained fairly stable at around 5.36% over the period 2006–2012, which is on average 4.4 times higher than the same ratio for the total economy (1.22 on average over the period). It increased slightly throughout the period, reaching a maximum of 5.59% in 2012. However, the range of fluctuation is small. Real growth rates, shown in Figure 11-b, reveal that in 2007 ICT sector BERD moved at an annual rate of -0.06%, around three percentage points lower than ICT sector VA (2.96%). From 2008 to 2010 both variables grew at a similar rate, but in 2011 the growth rate of ICT sector BERD was more than four times higher than ICT sector VA. In 2012, ICT sector BERD grew at a rate of 1.05% while the ICT sector VA showed a negative rate (-0.43%). The joint combination of these movements explains the relatively mild oscillations shown on the left-hand side of Figure 11.

Figure 11

a: ICT sector BERD share of ICT sector value added. European Union (2006–2012)



b: ICT sector BERD and VA annual real growth rates. European Union (2006–2012)



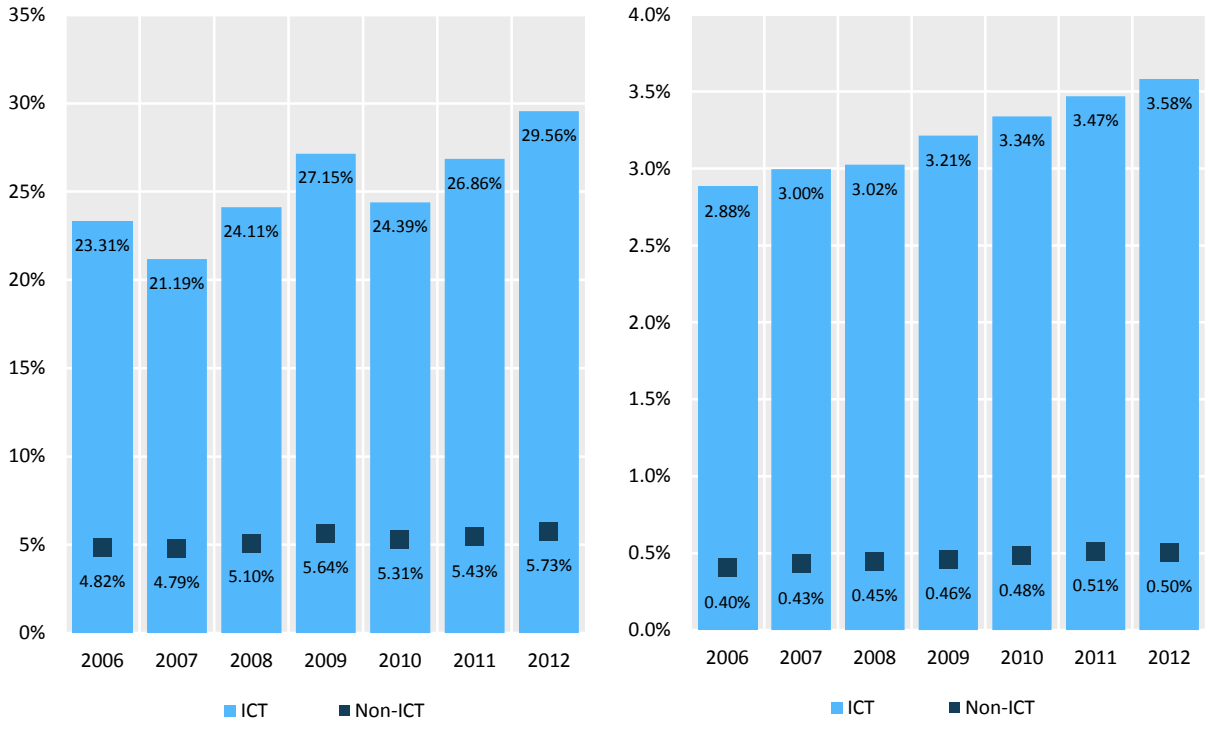
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 12 completes the information related to BERD intensity, showing that ICT manufacturing sectors have higher BERD intensity than ICT services. BERD intensity in ICT manufacturing sectors (29.56% in 2012) is 8.3 times higher than in ICT services (3.58%) and 22.4 times higher than total BERD intensity (1.32 in the same year). The differences persist in the case of non-ICT sector BERD intensity (5.73% for non-ICT manufacturing and 0.50% for non-ICT services).

BERD intensity grew significantly in ICT manufacturing sectors from 26.86% in 2011 29.56% in 2012, the highest value in the whole period. Intensity also grew in the case of services (3.47% in 2011 and 3.58% in 2012). Note also that BERD intensity for ICT manufacturing sectors was 4.8 times higher than for non-ICT manufacturing. In the case of services, BERD intensity for ICT services was seven times higher than non-ICT services.

Figure 12: ICT and non-ICT sector BERD intensity (BERD/VA). European Union (2006–2012)

a) Manufacturing ***b) Services***

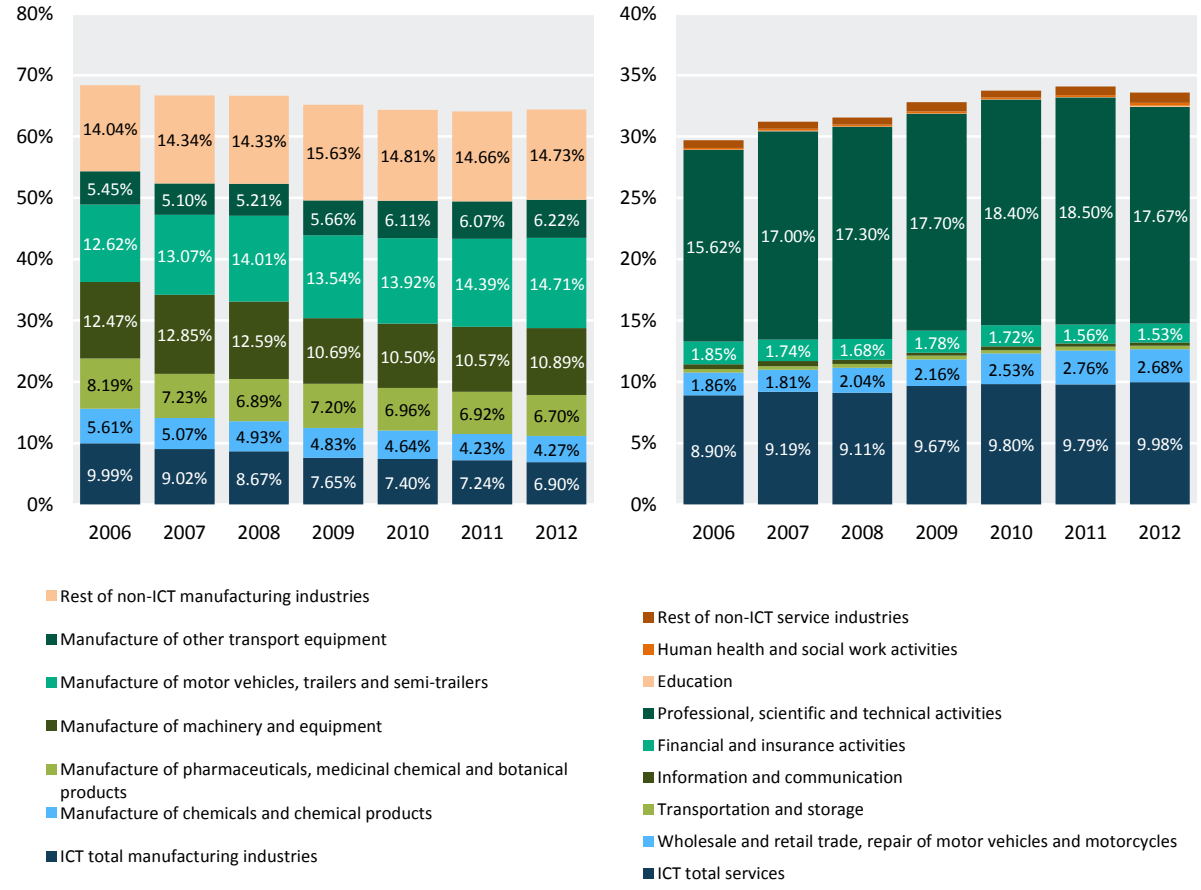


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 13 shows how total BERD is split among selected economic sectors. Figure 13-a provides the information for total manufacturing share as well as the share of the same selected sectors previously analysed. The first thing to note is that while manufacturing represents around 14% in terms of VA (Figure 3) and 15% in terms of employment (Figure 6), it accounted for around 66% in terms of BERD for the whole period. However, this was higher in 2006. On the other hand, ICT manufacturing sectors represent around 8.1% of total BERD on average, while their weights in terms of VA and employment are a scant 0.4%–0.5%. Again, it should be noted that this share also fell over the period, from 9.99% in 2006 to 6.90% in 2012. The two manufacturing sectors with the highest BERD share are *Manufacture of motor vehicles, trailers and semi-trailers* (14.71%) and *Manufacturing of machinery and equipment* (10.89%).

Figure 13: ICT sector BERD share of total BERD and comparison with non-ICT economic activities. European Union (2006–2012):

a) Manufacturing ***b) Services***



Note: Agriculture, forestry and fishing; Mining and quarrying; Electricity, gas, steam and air conditioning supply; Water supply, sewerage, waste management and remediation activities; and *Construction* are not included in either manufacturing or services industries.

Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 13-b provides the same information but referring to services, which represent around 32% of total BERD in the EU. ICT services sectors account for around 9.5% of total BERD but reflect an upward trend (8.90% in 2006 and 9.98% in 2012), which contrasts with the downward trend shown by ICT manufacturing. Besides ICT, the non-ICT sector with the highest share of total BERD is *Professional, scientific and technical activities*, which rose from 15.62% in 2006 to 17.67% in 2012. In the interpretation of the low shares corresponding to *Human health and social work activities*, together with *Education,* it is important to bear in mind that the BERD variable refers strictly to the business sector and not to the non-market economy, which has a significant weight in those two activities. Finally, it is interesting to note that, in contrast to the case of VA (Figure 3) and employment (Figure 6), the selected sectors absorb almost all BERD leaving practically no room for the other non-ICT sub-sectors (termed "rest of non-ICT industries") especially in services.

1.4 Public Funding of ICT R&D

In 2012, estimated ICT GBAORD in the EU amounted to 6.07 billion euros – 6.68% of the total EU GBAORD. In this analysis, the estimated public funding of ICT R&D is extracted from Government Budget and Appropriations or Outlays for R&D (GBAORD)[12], which is reported for 14 NABS-2007 chapters, as ICT R&D is included in several NABS chapters. For this reason, the estimation is based on the assumption that the share of ICT R&D expenditures in GBAORD is similar to the share of ICT R&D labour costs (from total R&D labour costs). Once a correspondence that links NABS chapters to NACE codes has been created, the Labour Force Survey (LFS) and the Structure of Earnings Survey (SES) are used to calculate ICT R&D labour shares separately for each NABS category, country and year. These shares are used to obtain an estimation of ICT GBAORD[13] for each country and year.

Figure 14-a shows ICT GBAORD intensity (defined as ICT GBAORD/GDP in the right-hand scale of the figure) in the EU for the years 2006–2012. It remained fairly stable at around 0.045%, reaching a maximum in 2009 of 0.051%. However, from 2009 it decreased slightly, falling to a share of 0.047% in 2012. Figure 1–14-a also shows the share of ICT GBAORD in total GBAORD, which amounted to around 6.6% during the period analysed. However, it went from 6.51% in 2006 to 6.68% in 2012, recovering from the declines suffered prior to 2008.

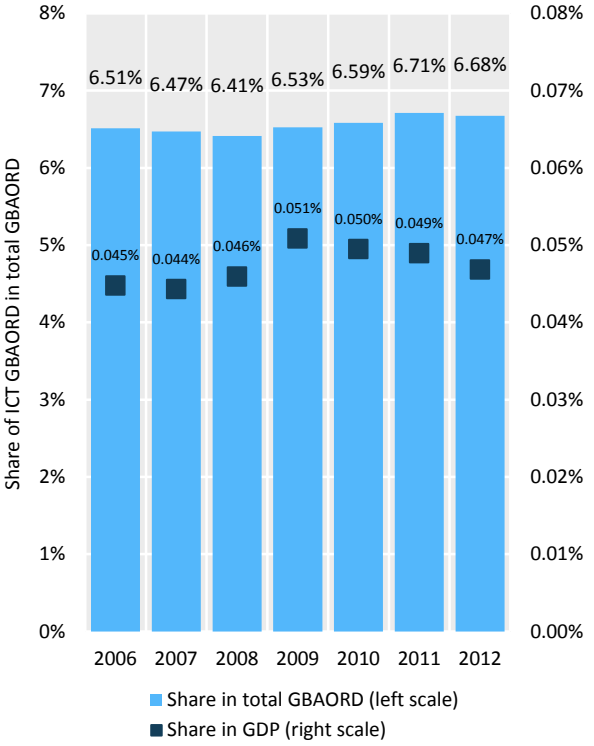
Figure 14-b provides the annual real growth rates of ICT GBAORD and total GBAORD[14]. Both variables followed similar paths, especially after 2008. In the years 2007 and 2008 total GBAORD showed higher growth rates than ICT GBAORD. However, in 2009, ICT GBAORD accelerated to reach a growth rate of 5.74% whereas total GBAORD began to slow down. 2010 showed a significant decline with negative growth rates for both variables. In 2011, total GBAORD (-1.41%) continued the negative rate of the previous year, whereas ICT GBAORD reached a positive growth rate (0.48%). Again in 2012, both total GBAORD (-4.19%) and ICT GBAORD (-4.69%) dropped sharply.

[12] Government Budget Appropriations or Outlays for R&D by Socio-economic Objectives (GBAORD) is a budget-based data, which allows government support for R&D to be measured. Essentially, this involves identifying all the budget items with an R&D component and measuring or estimating their R&D content in terms of funding. These estimates are less accurate than performance-based data but as they are derived from the budget, they can be linked to policy through classification by "objectives" or "goals". GBAORD series cover R&D in natural sciences, engineering, social sciences and humanities and in both current and capital expenditures. They include R&D performed on national territory as well as payments to foreign performers, including international organisations. GBAORD, however, covers only R&D financed by central government. Local government, and sometimes also provincial government, are excluded.

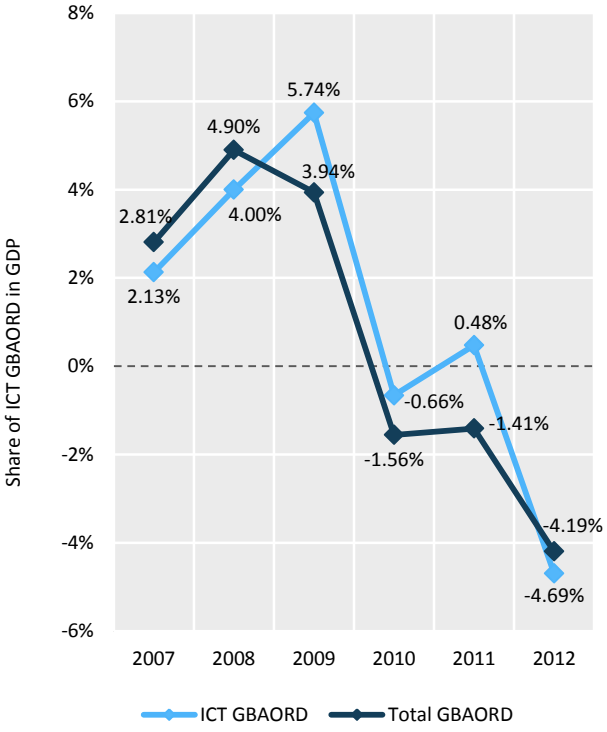
[13] For more detailed information on this estimation see Stančík, J., & Rohman, I. K. (2014). Public ICT R&D funding in the European Union. JRC Scientific and Policy Report. Available at: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC92883/jrc92883.pdf

[14] All growth rates are computed in real terms using the implicit GDP deflator (chained volume estimates or fixed-base volume estimates, depending on countries).

Figure 14
a: ICT GBAORD share in GDP and in total GBAORD. European Union (2006–2012)



b: ICT GBAORD and total GBAORD annual real growth rates. European Union (2006–2012)



Source: Eurostat, elaborated by Ivie and JRC-IPTS.

1.5 ICT sector R&D personnel

In 2006, R&D personnel in the EU ICT sector totalled 231.18 thousand workers and in 2012, 275.04 thousand, reflecting an increase of 43.87 thousand. At the same time, in 2006 the number of researchers in the EU ICT sector was 151.17 thousand, rising to 177.05 thousand in 2012, representing an increase of 25.88 thousand researchers in these seven years. Figure 15-a indicates that R&D personnel in the ICT sector accounts for around 4.1% of total ICT sector employment[15] in the EU for the period analysed (see the right-hand side for the scale of this variable). This share increased from 4.30 in 2010 to 4.45% in 2012. However, the sharpest growth was seen in 2010 (5.10%) and 2012 (4.44%). On the other hand, Figure 15-a also shows the share of ICT sector R&D researchers on ICT sector personnel (scale on the left-hand side). This ratio has fluctuated around a range of 63%–65%. The highest share, 65.39%, occurred in 2006, while a minimum was reached in 2009 (62.72%). This share was 64.37% in 2012, higher than in 2011 (62.99%).

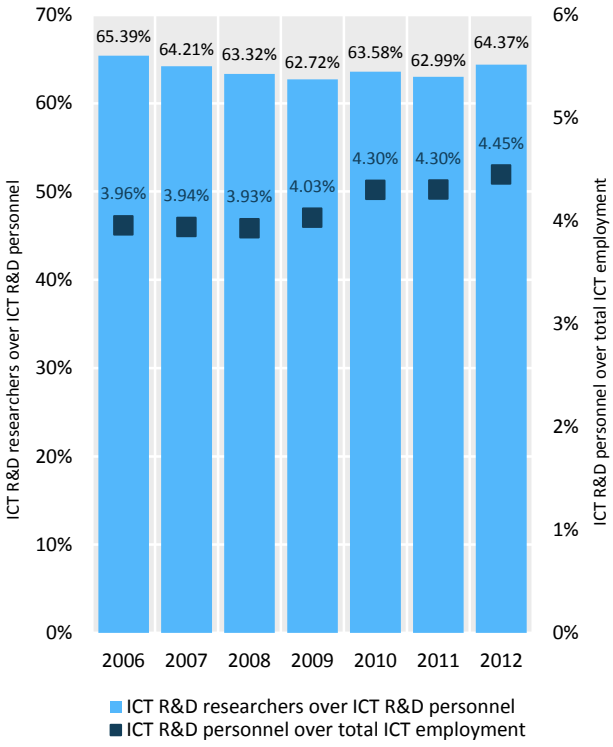
In the ICT sector, employment grew at a faster pace (around 3%) than R&D personnel (around 2.6%) or R&D researchers (around 1%) between 2006 and 2008, as reported in Figure 15-b. With

[15] The statistics available for all the countries provides the data for personnel in full-time equivalent (FTE) terms while employment is measured in terms of *headcounts*. The difference between the two indicators is due to the fact that not all persons engaged (head counts) are full-time employees. A full-time equivalent researcher is measured in such a way to make them comparable even though they may work or study a different number of hours.

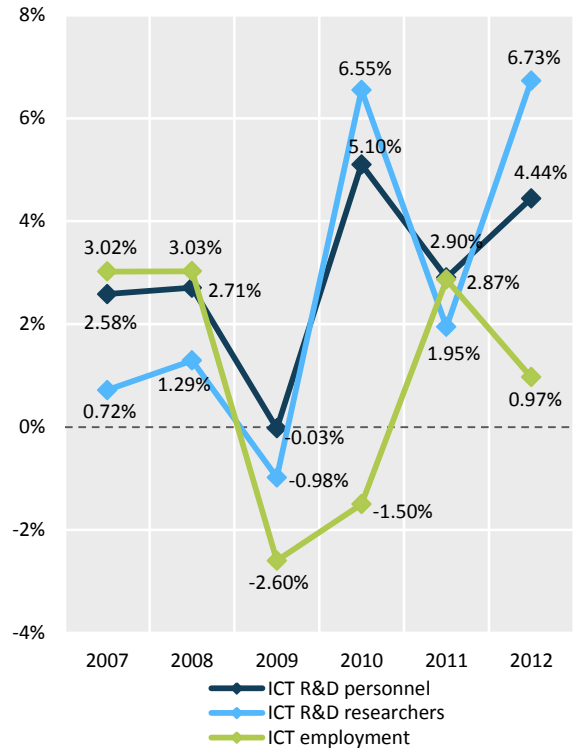
the onset of the recession, ICT sector employment shrank by -2.60%, while the negative growth rate was smaller in ICT sector R&D personnel (-0.03%) and researchers (-0.98%). In 2010, ICT sector employment began to recover but the growth rate was still negative (-1.50%), whereas ICT sector R&D researchers (6.55%) and personnel (5.10%) witnessed an upturn. In 2011, however, ICT sector employment recovered and grew at a rate of 2.87%, whereas ICT sector R&D personnel slowed down to 2.90% and ICT sector R&D researchers to 1.95%. In the last year with available data (2012) ICT employment grew around 1% whereas improvement for R&D personnel (4.44%) and researchers (6.73%) was faster.

Figure 15

a: ICT sector R&D personnel share of total ICT sector employment, and ICT sector R&D researchers share of ICT sector R&D personnel. European Union (2006–2012)



b: Annual growth rates of ICT sector employment, ICT sector R&D personnel and ICT sector R&D researchers. European Union (2006–2012)

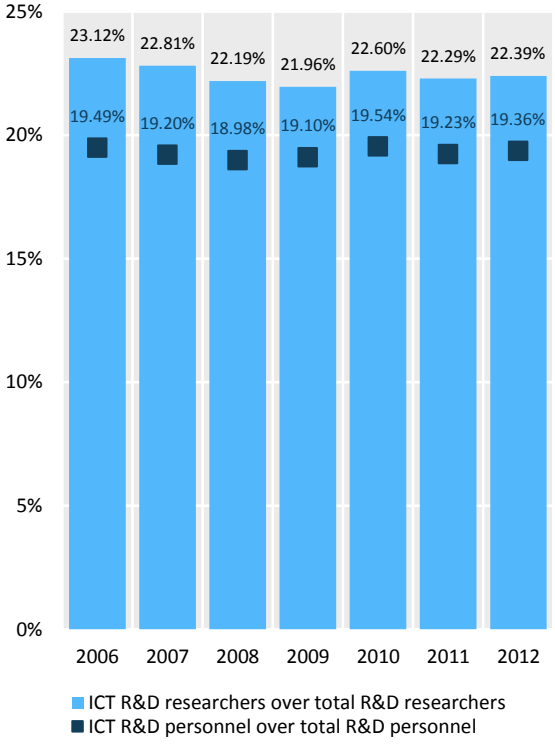


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

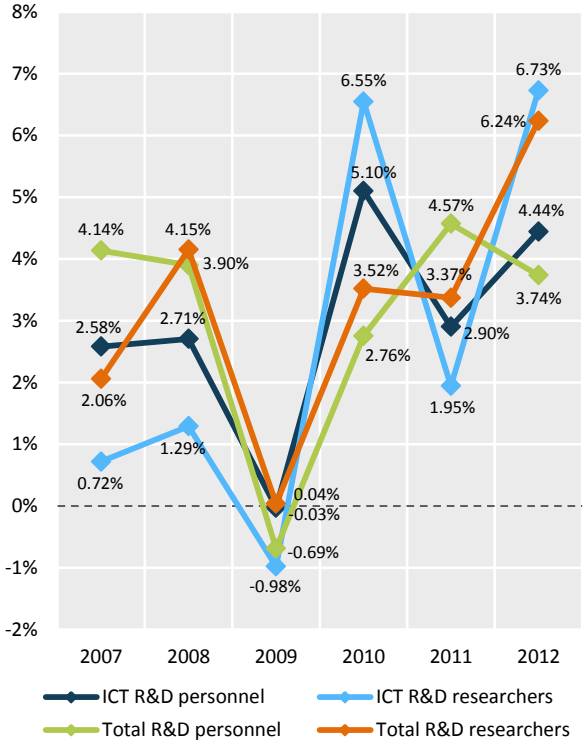
ICT sector R&D personnel accounted for 19.36% of total R&D personnel in 2012, while ICT R&D researchers amounted to 22.39% of total R&D researchers (Figure 1-16-a). The share of ICT sector R&D personnel was 19.49% in 2006 and then fell, reaching its lowest level in 2008 (18.98%), after which it remained fairly stable at around 19.3%–19.5%. The pattern for the ICT sector R&D researchers and personnel was similar. They both presented only negative growth rates between 2008 and 2009 (Figure 1-16-b), and high rates of growth in 2012 (6.73% for ICT R&D researchers and 4.44% for ICT R&D personnel). Thus, the falls in the ICT sector shares in the two variables are due to the greater dynamism registered in total R&D personnel and researchers. Note that after 2009 the number of ICT sector R&D personnel and researchers grew at an average annual rate of 4% and above 5%, respectively, creating around 10,500 jobs each year.

Figure 16

a: ICT sector R&D personnel share of total R&D personnel, and ICT sector R&D researcher share of total R&D researchers. European Union (2006–2012)



b: Annual growth rates of R&D personnel and researchers, ICT sector R&D personnel and ICT sector R&D researchers. European Union (2006–2012)

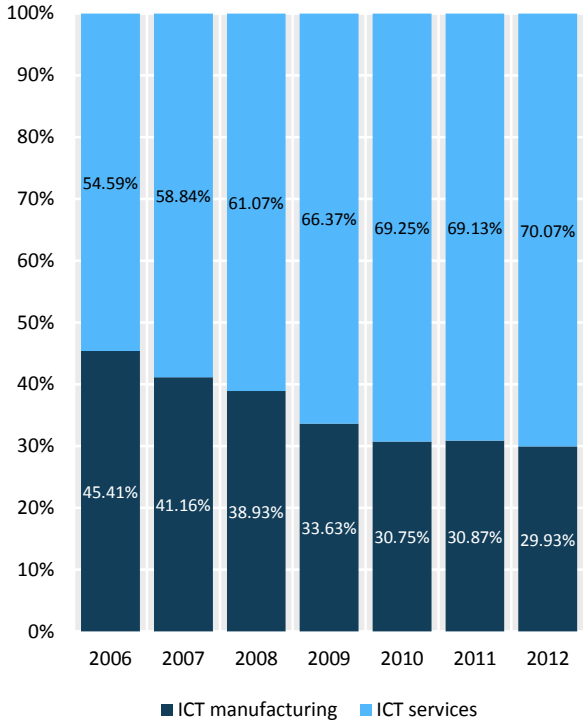


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

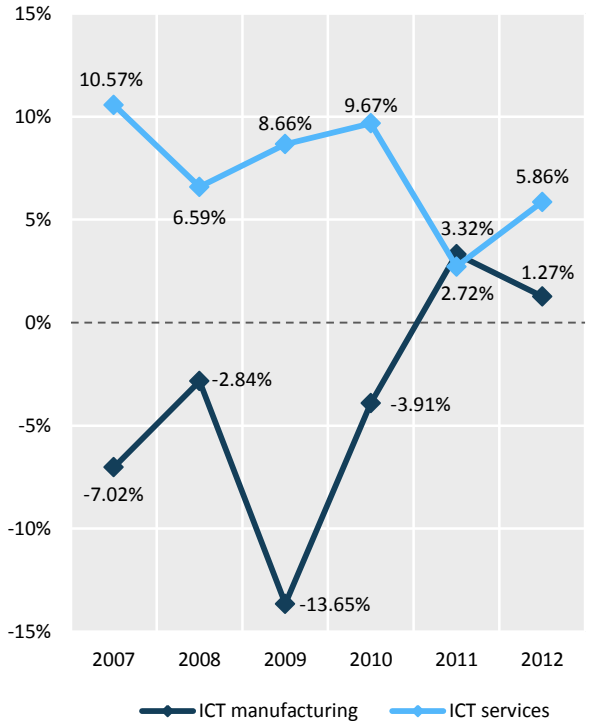
Figure 17-a shows how R&D personnel is split between ICT manufacturing and services sectors. Again, it is interesting to note that ICT manufacturing has declined in almost all variables. While ICT sector R&D personnel in manufacturing represented 45.41% of total ICT sector R&D personnel in 2006, seven years later this figure had fallen by around 15.5 percentage points to 29.93%. The striking fact is that while R&D personnel in the ICT services sectors retained its positive annual growth rates, even in the years of deep recession, the same cannot be said for ICT manufacturing sectors. In this case, the annual variation rate was constantly negative from 2007 to 2010. The annual rate of growth of ICT services R&D personnel in 2012 (5.86%) was 4.6 times higher than ICT manufacturing (1.27%).

Figure 17

a: Distribution of ICT sector R&D personnel shares for ICT manufacturing and ICT services. European Union (2006–2012)



b: Annual growth rates of ICT manufacturing R&D personnel and ICT services R&D personnel. European Union (2006–2012)

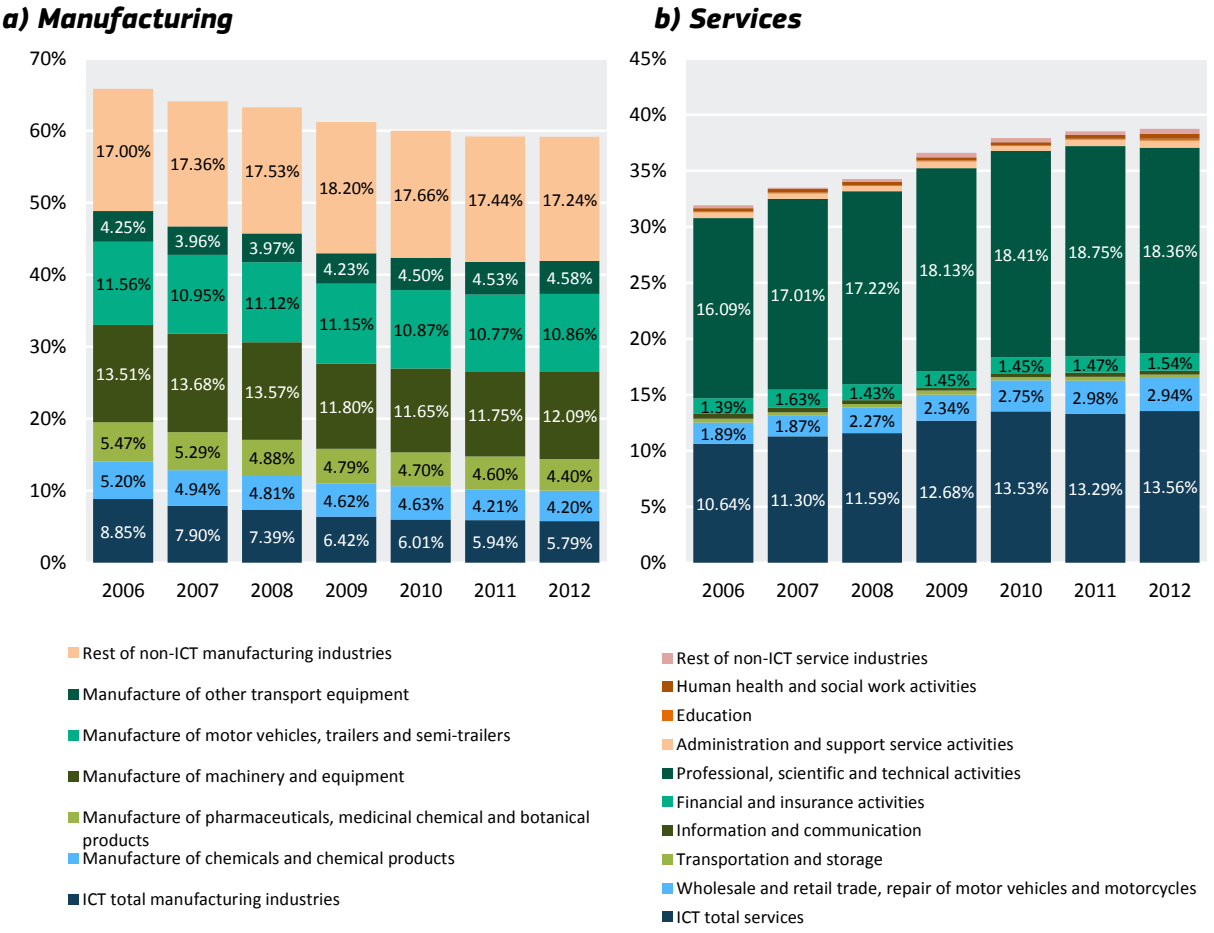


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Finally, Figure 18 shows the share of R&D personnel of the total for ICT and non-ICT sectors, differentiated according to manufacturing and services. As with BERD, the share of R&D personnel in manufacturing is higher than the shares in VA or employment (Figures 3-a and 6-a), but it showed a downward tendency. ICT sector R&D personnel in manufacturing fell from 8.85% in 2006 to 5.79% in 2012. As for BERD, the two manufacturing sectors with the highest share of R&D personnel are *Manufacture of machinery and equipment* and *Manufacture of motor vehicles, trailers and semi-trailers*, both of which lost share over the period.

By contrast R&D personnel in the services sector showed an upward trend that was very pronounced in the two sectors with the highest weight: *ICT Total services* went up from 10.64% in 2006 to 13.56% in 2012, and *Professional, scientific and technical activities* rose from 16.09% in 2006 to 18.36% in 2012. Thus, as with almost all variables, the services sector has shown remarkable resilience even in the most difficult years of the economic recession.

Figure 18: ICT sector R&D personnel share of total R&D personnel and comparison with non-ICT economic activities. European Union (2006–2012)



Note: Agriculture, forestry and fishing; Mining and quarrying; Electricity, gas, steam and air conditioning supply; Water supply, sewerage, waste management and remediation activities; and *Construction* are not included in either manufacturing or services industries.

Source: Eurostat, elaborated by Ivie and JRC-IPTS.

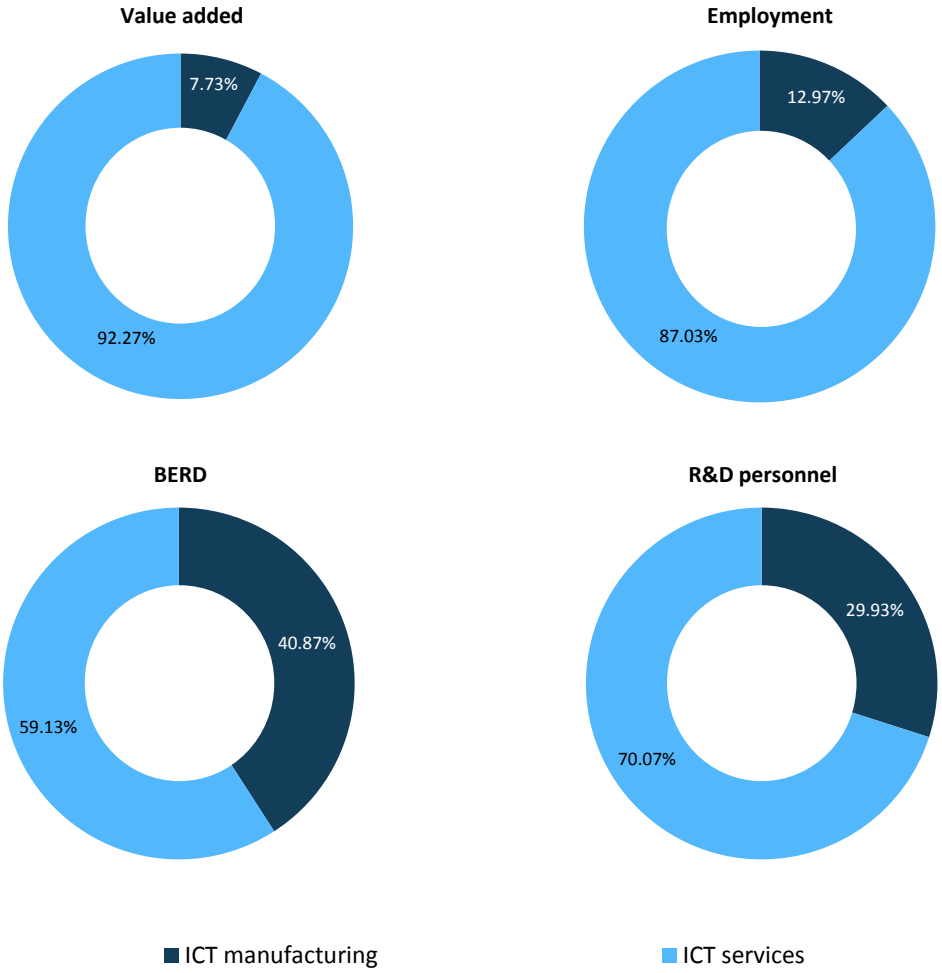
1.6 Comparison of indicators and data summary

Figure 1–19 provides a comparison of the distribution in the ICT manufacturing and ICT services sectors of the four main indicators analysed in this section –value added, employment, BERD and R&D personnel– for the European Union in 2012. The data summary for those variables is provided in Table 1–1. The main results of this comparison can be summarised as follows:

- ICT sector VA and ICT sector employment are concentrated in the ICT services sectors, especially in ICT sector VA, representing 92.27% of total ICT sector VA and 87.03% of total ICT sector employment in 2012. This path has grown steadily stronger since 2006. For example, in 2011 the ICT sector weights in VA and employment were 91.28% and 86.37% respectively.
- Compared with ICT services, the ICT manufacturing sector has a higher share in terms of BERD and R&D personnel than VA or employment, although this share has been declining since 2006. ICT sector BERD in manufacturing represented 40.87% of total ICT sector BERD in 2012 (42.51% in 2011), while the share of ICT manufacturing R&D personnel of the total amounted to 29.23% (30.87% in 2011).

– ICT GBAORD grew between 2006 and 2011 both in terms of its share in GDP (from 0.045% to 0.049%) and especially in its share of total GBAORD (from 6.51% to 6.71%). But these levels fell to 0.047% and 6.68%, respectively, in 2012.

Figure 19: Comparison of ICT manufacturing and services for value added, employment, BERD and R&D personnel. European Union (2012)



Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Table 2 summarises the main variables reviewed in this chapter.

Table 2: Summary table of ICT indicators by broad sectors. European Union (2012)

	ICT sector Value added	ICT sector Employment	ICT sector BERD	ICT GBAORD[16]	ICT sector R&D personnel
	(Millions of current EUR)	(thousand persons employed)	(Millions of current EUR)	(Millions of current EUR)	(thousand full-time equivalent)
ICT total manufacturing	39,917.85	801.27	11,799.31	-	82.33
ICT total services	476,579.61	5,378.23	17,067.93	-	192.71
ICT total	**516,497.46**	**6,179.50**	**28,867.24**	**6,067.34**	**275.04**

Source: Eurostat, elaborated by Ivie and JRC-IPTS.

[16] Following NABS chapter classification thus not available in NACE category.

2. Analysis by ICT sub-sector

2.1 ICT sector value added

ICT sector value added (VA) amounted to 516.50 billion euros in 2012. This represented a share of 3.99% of EU GDP, a share that has declined slightly over the last few years. ICT services contributed by far the largest share of ICT sector VA (92.27%, or 476.58 billion euros in 2012), accounting for 3.68% of EU GDP, while ICT manufacturing VA contributed 7.73% of ICT sector VA (39.92 billion euros), totalling 0.31% of GDP.

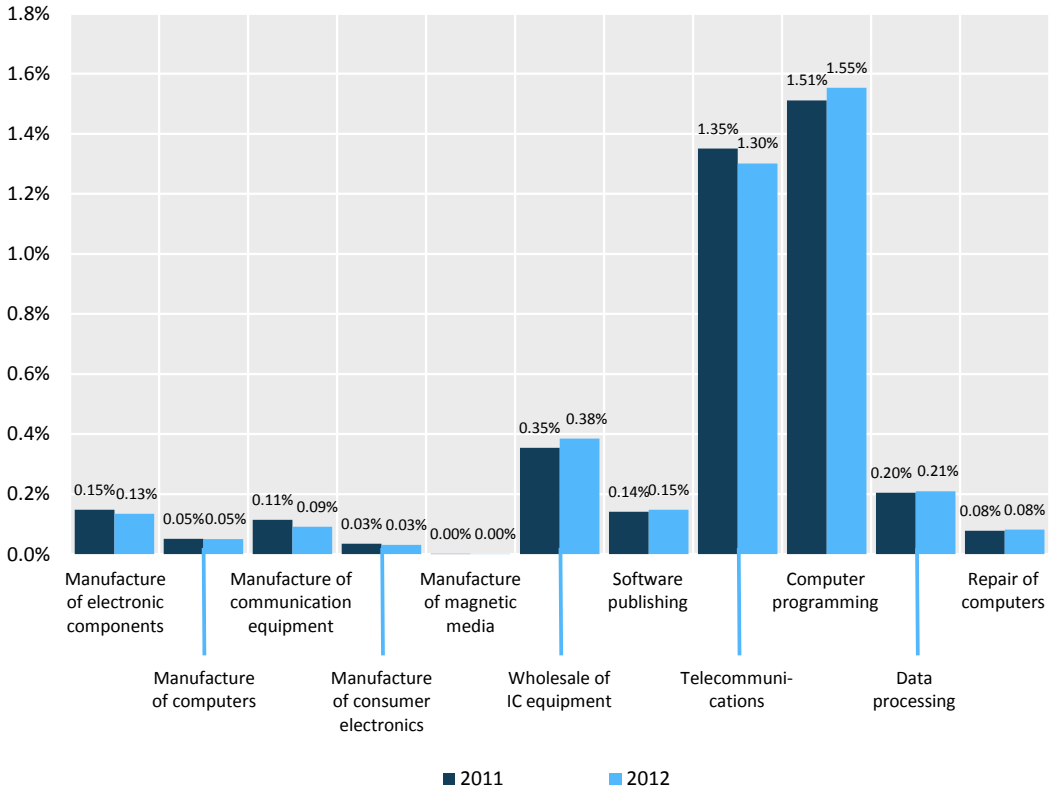
Figure 20 plots the ICT sector VA share of GDP by ICT sub-sectors. By far the two largest ICT service sub-sectors in the EU are *Computer programming, consultancy and related activities*, which generated a VA of 201.29 billion euros in 2012 (1.55% of EU GDP), and *Telecommunications,* producing a VA of 168.62 billion euros in 2012 (1.30% of EU GDP). These two sub-sectors represented almost 72% of the total VA produced by the ICT sector in 2012. *Wholesale of IC equipment –Wholesale of computers, computer peripheral equipment and software* and *Wholesale of electronic and telecommunications equipment and parts*– generated a VA of 49.81 billion euros in 2012, or 0.38% of EU GDP. In 2012, the value added created in ICT manufacturing was lower than the VA produced in *Wholesale of IC equipment*. From 2011 to 2012, the value added generated by ICT services increased by 13.95 billion euros (a 3.02% increase in nominal terms and 0.65% in real terms).

Box 1: List of NACE Rev. 2 ICT sub-sectors:

Nace Rev. 2	Description
261-264, 268	**ICT manufacturing industries**
261	Manufacture of electronic components and boards
262	Manufacture of computers and peripheral equipment
263	Manufacture of communication equipment
264	Manufacture of consumer electronics
268	Manufacture of magnetic and optical media
465, 582, 61, 62, 631, 951	**ICT total services**
465	**ICT trade industries**
4651	Wholesale of computers, computer peripheral equipment and software
4652	Wholesale of electronic and telecommunications equipment and parts
5820, 61, 62, 631, 951	**ICT services industries**
5820	Software publishing
61	Telecommunications
62	Computer programming, consultancy and related activities
631	Data processing, hosting and related activities; web portals
951	Repair of computers and communication equipment

The two largest ICT manufacturing sub-sectors in the EU are *Manufacturing of electronic components and boards* and *Manufacturing of communication equipment*. Their cumulative contribution to EU GDP was, however, only 0.23% in 2012. From 2011 to 2012, value added produced by ICT manufacturing decreased by 4.26 billion euros (-9.64% in nominal terms and -11.71 in real terms). The joint weight represented by two of the key ICT sub-sectors, *Telecommunications* and *Communication equipment*, 1.39% of GDP, is also notable.

Figure 20: ICT sector VA share of GDP by sub-sector (2011, 2012)

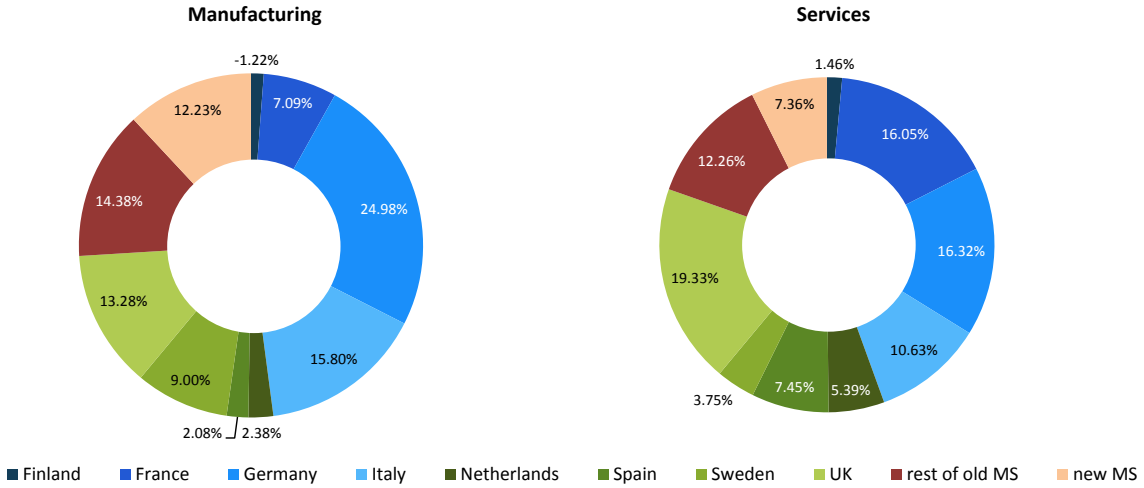


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 21 provides a comparison of ICT manufacturing and services sectors in terms of Member State contributions to ICT sector VA in 2012. On the one hand, Germany (24.98%) dominated ICT manufacturing, followed by Italy (15.80%), the UK (13.28%), Sweden (9.00%) and France (7.09%). On the other hand, the ICT services sector was dominated by a group of four countries –the UK (19.33%), Germany (16.32%), France (16.05%) and Italy (10.63%)– that represented 62.32% of the total EU ICT services VA. Thus there are noticeable differences between countries according to different specialisation patterns. Some countries play a leading role in ICT manufacturing while their importance in terms of ICT services is lower. These differences can have important implications for each country, as ICT services have proved to be more resilient during the recession, but on the other hand, higher shares of ICT manufacturing imply generally higher shares in terms of BERD. The biggest differences in Member States' contributions can be seen in France (7.09% in manufacturing vs. 16.05% in services), Germany (24.98% vs. 16.32%), the UK (13.28% vs. 19.33%), Spain (2.08% vs. 7.45%) and Sweden (9.00% vs. 3.75%). The thirteen new Member States[17] contributed more to ICT sector VA in ICT manufacturing (12.23%) than in ICT services (7.36%), probably because of the offshoring of activities towards these new Member States.

[17] New Member States: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

Figure 21: Comparison of ICT manufacturing and services: distribution of VA among the biggest Member State contributors (2012)



Note: New MS are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia. Rest of old MS are Austria, Belgium, Denmark, Greece, Ireland, Luxembourg and Portugal.

Note: Finland shows a negative value for year 2012 due to a few large enterprises logging much higher expenditures in income statement then previous years.

Source: Eurostat, elaborated by Ivie and JRC-IPTS.

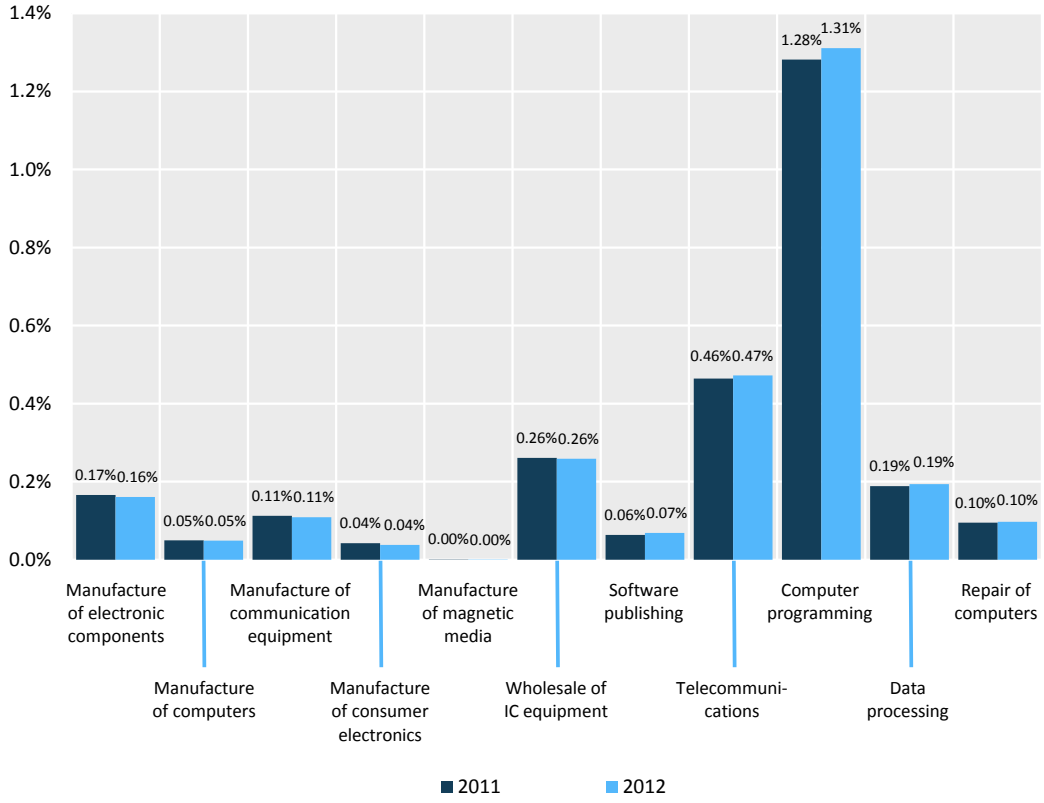
2.2 ICT sector employment and ICT sector labour productivity

2.2.1 ICT sector employment

In 2012, 6.18 million people worked in the EU ICT sector, representing 2.76% of total employment. ICT sector employment is highly concentrated in ICT services: 5.38 million people worked in ICT services (87.03%) whereas 0.80 million worked in ICT manufacturing (12.97%). Overall ICT sector employment increased by 0.97% –in absolute terms, almost 59 thousand people– from 2011 to 2012. This figure represented job losses in ICT manufacturing (-33 thousand people, -3.96%) and job creation in ICT services (92 thousand people, 1.75%). It is important to note the different behaviour in the ICT sector: ICT manufacturing lost jobs, while ICT services generated employment.

Figure 22 plots the ICT sector employment share of total employment by ICT sub-sectors. As in the case for VA, ICT sector employment in the EU is concentrated in just two service sectors, *Computer programming, consultancy and related activities*, with 2.94 million people (1.31% of total employment), and *Telecommunications* with 1.06 million people (0.47% of total employment). In 2012, these two sub-sectors represented 64.63% of total ICT sector employment. *Wholesale of IC equipment* is the only ICT services sub-sector that showed a slightly lower share in 2012.

Figure 22: ICT sector employment share of total employment by sub-sector (based on head counts; 2011, 2012)

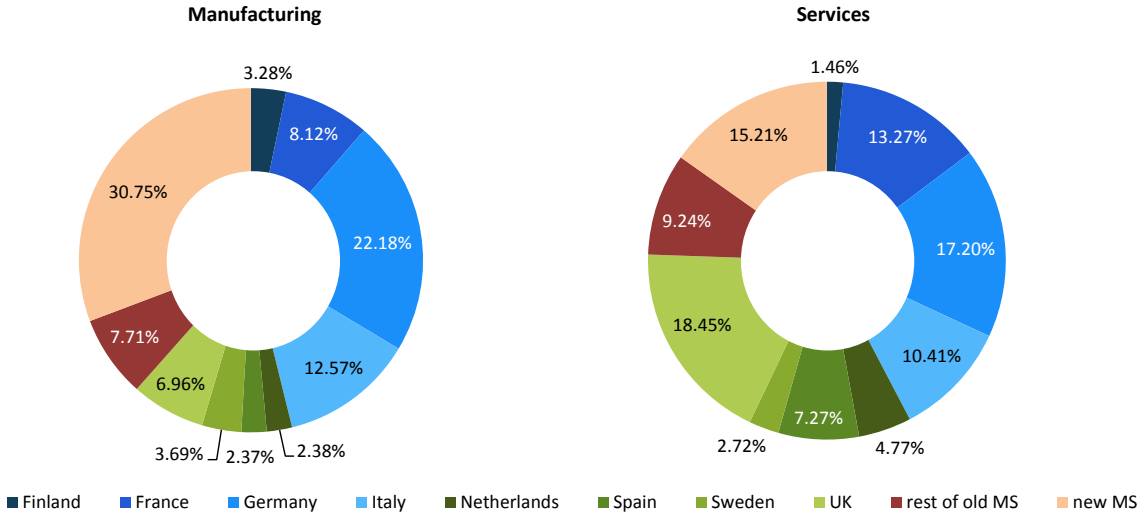


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

In ICT manufacturing, most employment is provided by two sub-sectors: *Manufacturing of electronic components and boards* employs 0.36 million people (0.16% of total employment) and *Manufacturing of communication equipment* employs 0.24 million people (0.11% of total employment).

From 2011 to 2012, ICT services employment increased in absolute terms in *Computer programming, consultancy and related activities* by 2.03% and decreased by 1.06% in *ICT trade industries*, the only ICT services sub-sector that showed negative growth. Employment increased by 7.45% (10.70 thousand people) in *Software publishing*, 1.50% (15.68 thousand people) in *Telecommunications,* 2.45% (10.19 thousand people) in *Data processing* and also increased by 1.77% (3.80 thousand people) in *Repair of computers* in 2012. In ICT manufacturing, employment decreased by 10.40% in *Manufacture of consumer electronics,* 3.76% in *Manufacture of communication equipment* and by 3.29% in *Manufacture of electronic components.* All ICT manufacturing sub-sectors destroyed employment between 2011 and 2012.

Figure 23: Comparison of ICT manufacturing and services: distribution of ICT sector employment among the biggest Member State contributors (2012)



Note: New MS are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia. Rest of old MS are Austria, Belgium, Denmark, Greece, Ireland, Luxembourg and Portugal.
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 23 provides a comparison of employment in the ICT manufacturing and services sectors by MS in 2012. The most striking observation is the contribution of the new Member States. These 13 countries together employed 30.75% of all employees from the EU ICT manufacturing sector, significantly above the 22.18% employed by Germany. One of the explanations for this fact is the relocation[18] of production activities, especially in manufacturing, from the EU-15 to newer Member States. In services, however, the contribution of the new MS was only half that value (15.21%). In terms of single-country contributions, Germany dominated ICT manufacturing (providing 22.18% of EU ICT manufacturing employment) and ICT services employment was concentrated in the UK (18.45% of EU). France and Italy together contributed 49.83% and 59.33% to total EU ICT manufacturing and services employment, respectively. The differences between individual country shares (manufacturing vs. services) are significant in the UK (6.96% share in manufacturing vs. 18.45% share in services), Germany (22.18% vs. 17.20%), Spain (2.37% vs. 7.27%) and France (8.12% vs. 13.27%).

2.2.2 ICT sector labour productivity

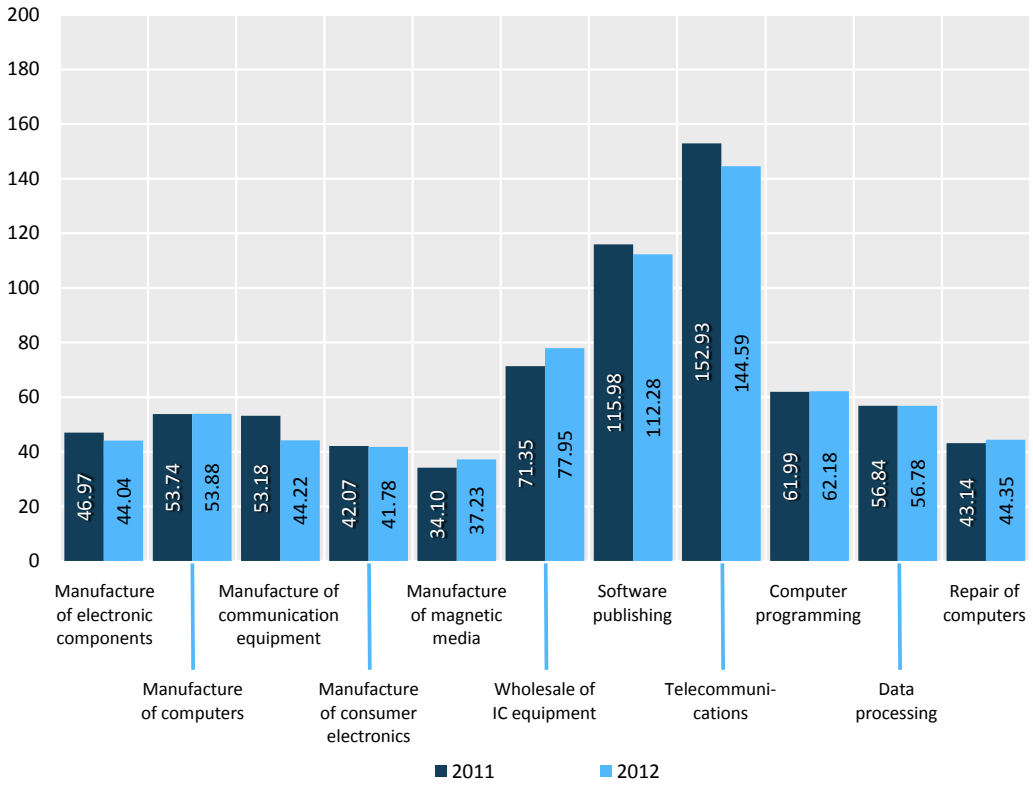
In 2012, labour productivity per person in ICT manufacturing in the EU was 45.18 thousand constant euros, while the figure for ICT services was 80.37 thousand constant euros. The highest labour productivity was achieved in *Telecommunications*, rising to more than 144 thousand euros (see Figure 24). Between 2011 and 2012, ICT sector labour productivity in the EU decreased by -1.38% in real terms[19]. This decrease was more intense in ICT manufacturing (-8.07%) than in

[18] See Timmer, Marcel P., Bart Los, Robert Stehrer, and Gaaitzen J. de Vries (2013). 'Fragmentation, Incomes and Jobs. An Analysis of European Competitiveness', *Economic Policy*, 28(76), 613– 61; and Marin, D. (2006). 'A new international division of labor in Europe: outsourcing and offshoring to Eastern Europe', *Journal of the European Economic Association*, 4(2–3), 612–22.

[19] All growth rates are computed in real terms using the implicit GDP deflator (chained volume estimates or fixed-base volume estimates, depending on countries).

services (-1.08%). The biggest rise was recorded in *Wholesale of IC equipment* (9.25%) and *Manufacture of magnetic media* (9.17%), while the biggest drop was in *Manufacture of communication equipment*, which fell by around 16.90%. In *Telecommunications* labour productivity dropped from 152.93 thousand constant euros per person in 2011 to 144.59 one year later.

Figure 24: ICT sector labour productivity by sub-sector (thousand constant [base year 2005] EUR per person; 2011, 2012)



Source: Eurostat, elaborated by Ivie and JRC-IPTS.

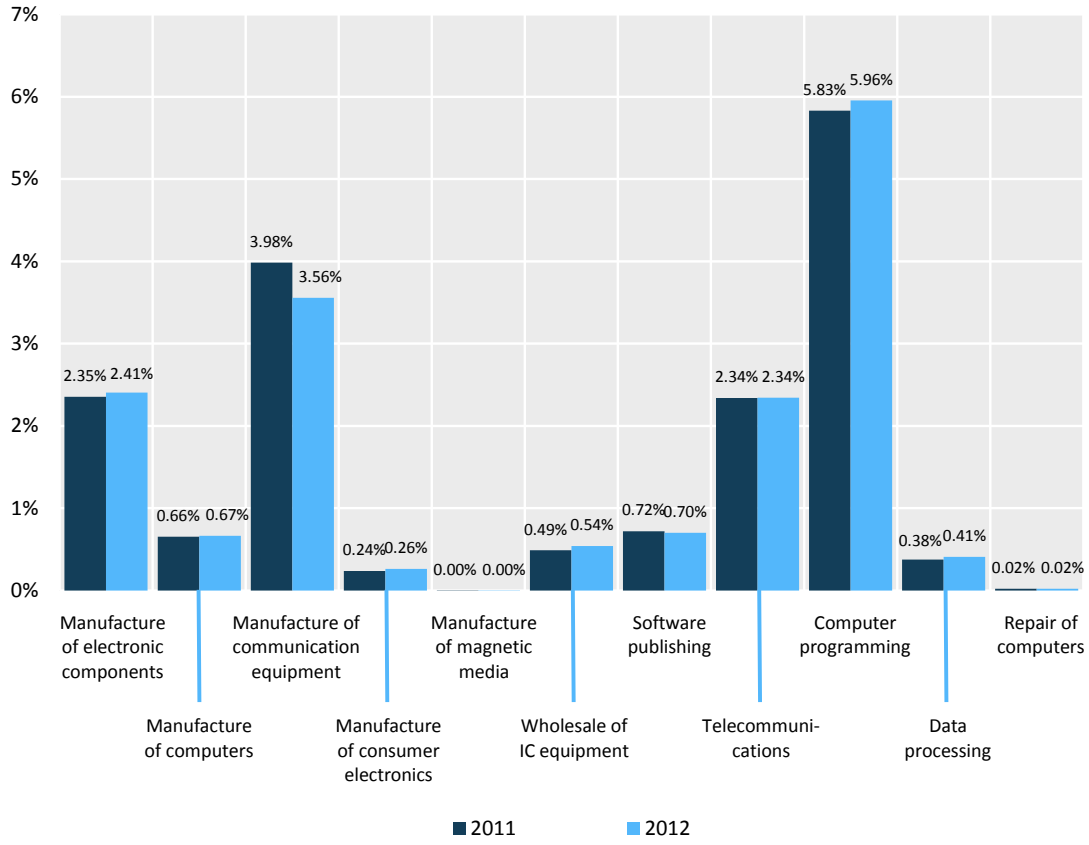
2.3 ICT sector business enterprise R&D (BERD) expenditure

Analysing ICT sector business enterprise expenditure on R&D (ICT sector BERD) across ICT sub-sectors provides a quite different perspective to the picture resulting from a comparison of value added or employment (see Figure 25).

In 2012, ICT sector BERD amounted to 28.87 billion euros, 3.42% more than in 2011 in nominal terms, which meant a growth of 1.05% in real terms. This amount was divided between manufacturing (11.80 billion euros) and services (17.07 billion euros).

In 2012, more than half ICT manufacturing BERD (51.59%) was invested in *Manufacturing of communication equipment* (6.09 billion euros, or 3.56% of total BERD in the EU economy), and 34.88% in *Manufacturing of electronic components and boards* (4.12 billion euros). More than half ICT services BERD (59.70%) was invested in *Computer programming, consultancy and related activities* (10.19 billion euros), and 23.50% in *Telecommunications* (4.01 billion euros).

Figure 25: ICT sector BERD share in total BERD by sub-sector (2011, 2012)

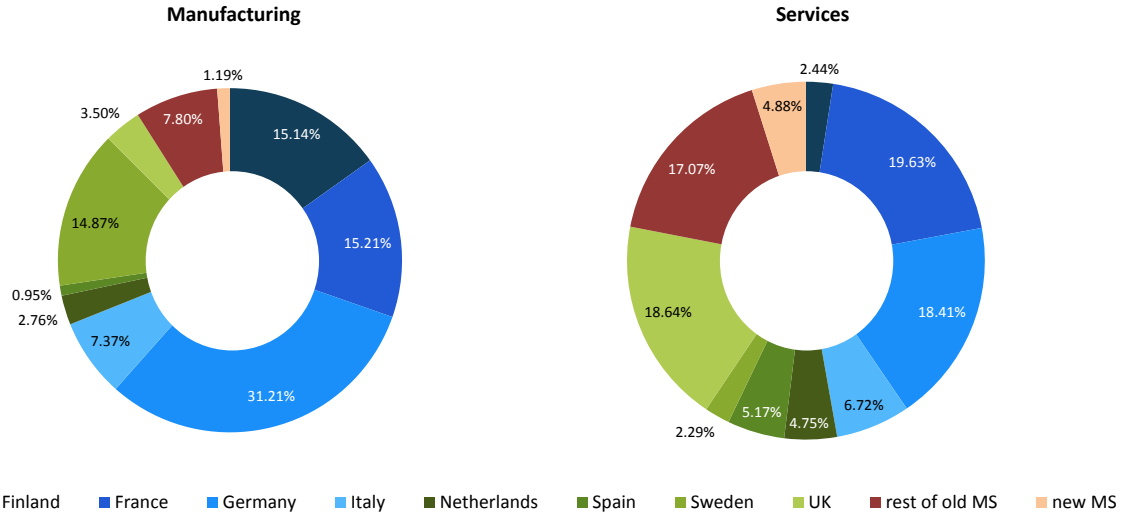


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

From 2011 to 2012, ICT manufacturing BERD dropped at a rate of -0.55% in nominal terms, which meant a decline of -2.84% in real terms. *Manufacturing of communication equipment* experienced the biggest decrease in nominal terms (-6.84%, 0.45 billion euros in absolute terms). The rest of ICT manufacturing sub-sectors grew, especially *Manufacture of electronic components* (by 0.26 billion euros, 6.65%). In ICT services, BERD grew by 6.36% in nominal terms (3.92% in real terms), mostly in *Computer programming, consultancy and related activities* (by 0.62 billion euros) and *Data processing, hosting and related activities; web portals*, by 10.42% in real terms.

Figure 26 provides a comparison of the ICT manufacturing and services sectors in terms of Member States' contributions to ICT sector BERD in 2012. ICT manufacturing was dominated by Germany (31.21%), France (15.21%), Finland (15.14%) and Sweden (14.87%), representing 76.43% of the total EU ICT manufacturing BERD. However, when ICT services BERD is considered, Finland (2.44%) and Sweden (2.29%) contributed by less than 3% each, in sharp contrast to their contribution to ICT manufacturing BERD, which was 30.01% in total. In contrast, France (19.63%), United Kingdom (18.64%) and Germany (18.41%) held leading positions in services. The UK, France and Spain are among the Member States with larger BERD contributions in ICT services than in ICT manufacturing: the UK (3.50% vs. 18.64%), France (15.21% vs. 19.63%) and Spain (0.95% in manufacturing vs. 5.17% in services).

Figure 26: Comparison of ICT manufacturing and services: distribution of ICT sector BERD among the biggest Member State contributors (2012)



Note: New MS are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia. Rest of old MS are Austria, Belgium, Denmark, Greece, Ireland, Luxembourg and Portugal.

Source: Eurostat, elaborated by Ivie and JRC-IPTS.

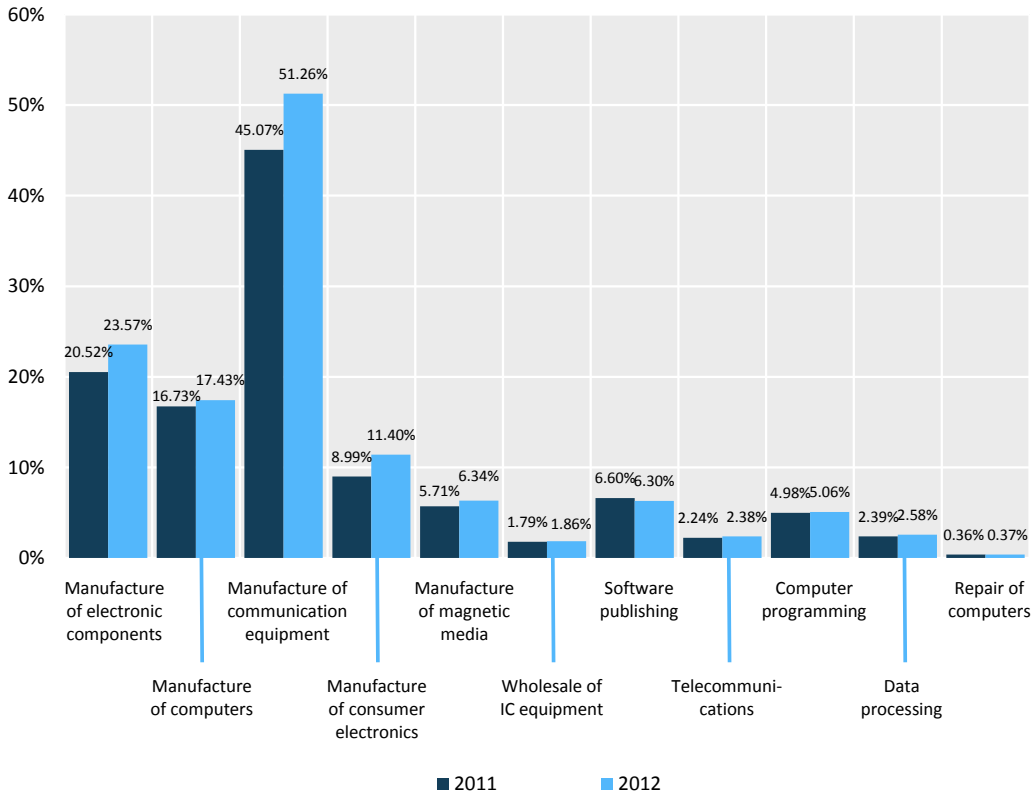
The ICT sector is one of the most R&D-intensive sectors in the EU economy. In 2012, ICT sector BERD made up 16.87% of total BERD, while ICT sector VA represented only 3.99% of GDP. In the same year, ICT sector BERD intensity, measured by the ratio of ICT sector BERD to ICT sector VA, was, at 5.59%, 0.08 percentage points higher than its 2011 value of 5.51%. In the meantime, total BERD intensity increased only by 0.03 percentage points in 2012, from 1.29% in 2011 to 1.32% (see Figure 11-a).

In 2012, although ICT manufacturing sub-sectors produced only 7.73% of ICT sector value added, they accounted for 40.87% of ICT sector BERD. ICT manufacturing sub-sectors are much more R&D intensive than ICT services sub-sectors. In fact, BERD intensity is 8.25 times higher in ICT manufacturing (29.56%) than in ICT services (3.58%).

Figure 27 provides a comparison of BERD intensity among ICT sub-sectors. BERD intensity was particularly high, especially in one ICT manufacturing sub-sector: 51.26% in *Manufacturing of communication equipment*, which even increased between 2011 and 2012. From 2011 to 2012, ICT manufacturing BERD decreased by -2.84% in real terms, and ICT manufacturing VA decreased by -11.71% also in real terms[20]. This difference resulted in an increase in BERD intensity in ICT manufacturing from 26.86% in 2011 to 29.56% in 2012.

[20] All growth rates are computed in real terms using the implicit GDP deflator (chained volume estimates or fixed-base volume estimates, depending on countries).

Figure 27: ICT sector BERD intensity (ICT BERD/ICT VA) by sub-sector (2011, 2012)



Source: Eurostat, elaborated by Ivie and JRC-IPTS.

From 2011 to 2012, BERD in ICT services increased by 3.92% in real terms. In 2012 more than half BERD in ICT services (59.70%) corresponded to *Computer programming, consultancy and related activities* (10.19 billion euros), and 23.50% in *Telecommunications* (4.01 billion euros). BERD intensity in ICT services increased slightly between 3.47% and 3.58%, although it was significantly lower in ICT services than in most ICT manufacturing sub-sectors. This indicator reached 6.30% in *Software publishing*, 5.06% in *Computer programming, consultancy and related activities*, 2.58% *in Data processing* and 2.38% in *Telecommunications.*

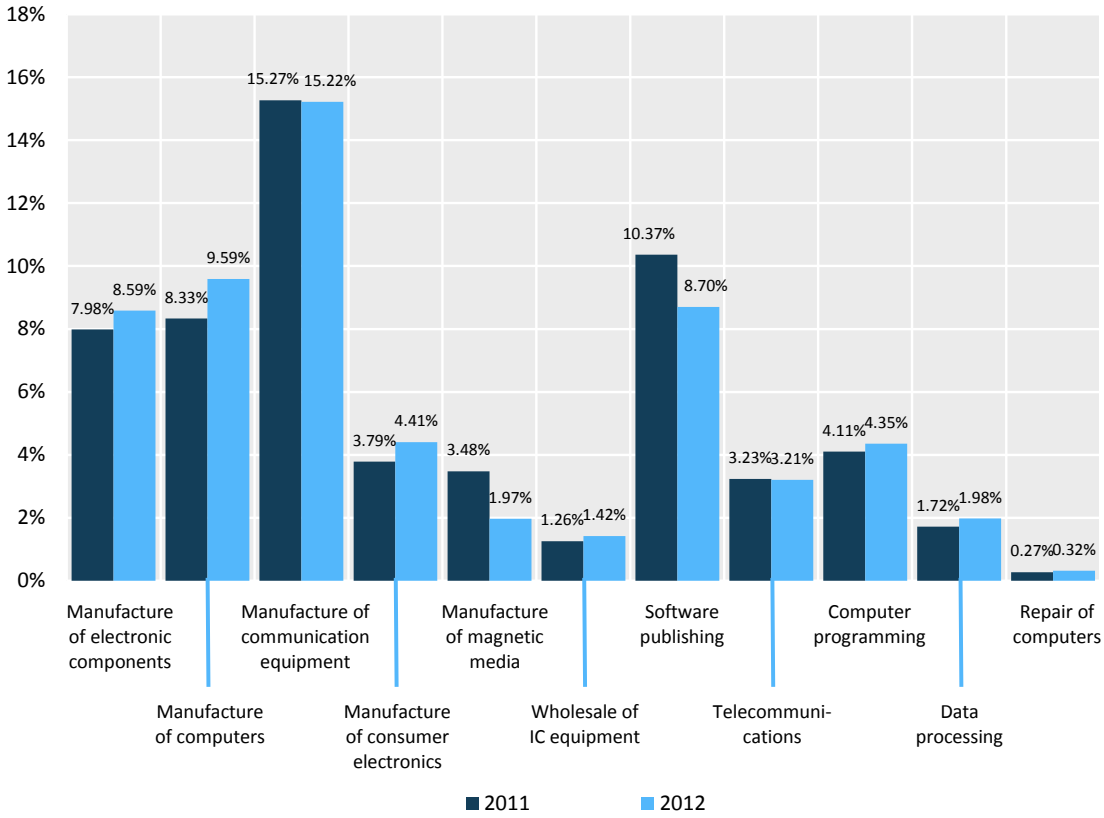
In terms of variation, BERD increased mostly in *Computer programming, consultancy and related activities* (by 4.09% in real terms), in *Data processing* (by 10.42%) and in *Telecommunications* (2.08%) and decreased in *Software publishing* by -0.75% in real terms.

2.4 ICT sector R&D personnel

ICT sector R&D personnel (including both researchers and R&D supporting staff) made up 4.45% of total ICT sector employment in the EU in 2012. In this year, 10.27% of employees in the EU ICT manufacturing sub-sectors were R&D personnel, whereas the figure for ICT services was only 3.58%. According to Figure 28, the ICT sub-sectors with the highest share of R&D personnel were *Manufacture of communication equipment* (15.22%), *Manufacture of computers* (9.59%), *Software publishing* (8.70%) and *Manufacture of electronic components* (8.59%). In contrast, the ICT sub-sectors with the lowest shares of R&D personnel were *Wholesale of IC equipment*, *Manufacture of magnetic media, Data processing, hosting and related activities; web portals* and *Repair of computers and communication equipment*; each sub-sector employed less than 2%. *Telecommunications* and *Computer programming* also showed low shares in 2011 (3.21% and 4.35%, respectively).

There were around 275.04 thousand R&D employees working in the EU ICT sector in 2012, 4.44% more than in 2011. This is the result of a 1.27% increase in ICT manufacturing R&D employment (from around 81.30 thousand employees in 2011 to 82.33 thousand in 2012) and a 5.86% increase in ICT services employment (from 182.05 thousand employees in 2011 to 192.72 thousand in 2012). The increase in ICT manufacturing personnel occurred mainly in the *Manufacture of computers, Manufacture of electronic components and Manufacture of consumer electronics* sub-sectors, while the largest increases in ICT services personnel occurred in *Repair of computers and communication equipment, Data processing and Computer programming* and *ICT trade*. Similar trends are observed in the numbers of ICT sector researchers.

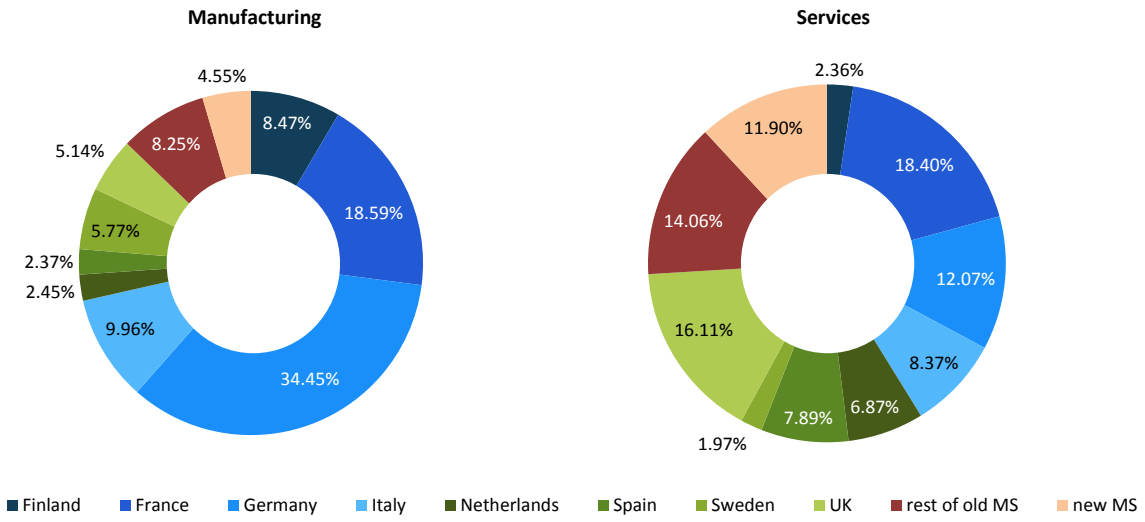
Figure 28: ICT sector R&D personnel share of total ICT sector employment by sub-sector (based on FTE; 2011, 2012)



Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 29 compares the share of ICT sector R&D personnel employed in the ICT manufacturing sector and the ICT services sector by Member State in 2012. On the one hand, similarly to previous indicators, Germany (34.45%) has the highest share of EU ICT manufacturing R&D personnel, followed by France (18.59%) and Italy (9.96%). These three countries alone account for 63.00% of the total EU ICT manufacturing R&D personnel. On the other hand, in ICT services the highest share corresponds to France (18.40%), followed by the UK (16.11%) and Germany (12.07%). Finland, which employs a significant portion of EU ICT manufacturing R&D personnel (8.47%), accounts for only 2.36% of ICT services R&D personnel. A large difference in ICT sector R&D personnel employment figures can also be observed in Germany (34.45% in manufacturing vs. 12.07% in services), the UK (5.14% in manufacturing vs. 16.11% in services), Spain (2.37% vs. 7.89%), the Netherlands (2.45% vs. 6.87%) and Sweden (5.77% in manufacturing vs. 1.97% in services).

Figure 29: Comparison of ICT manufacturing and services: distribution of ICT sector R&D personnel among the biggest Member State contributors (2012)



Note: New MS are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia. Rest of old MS are Austria, Belgium, Denmark, Greece, Ireland, Luxembourg and Portugal.

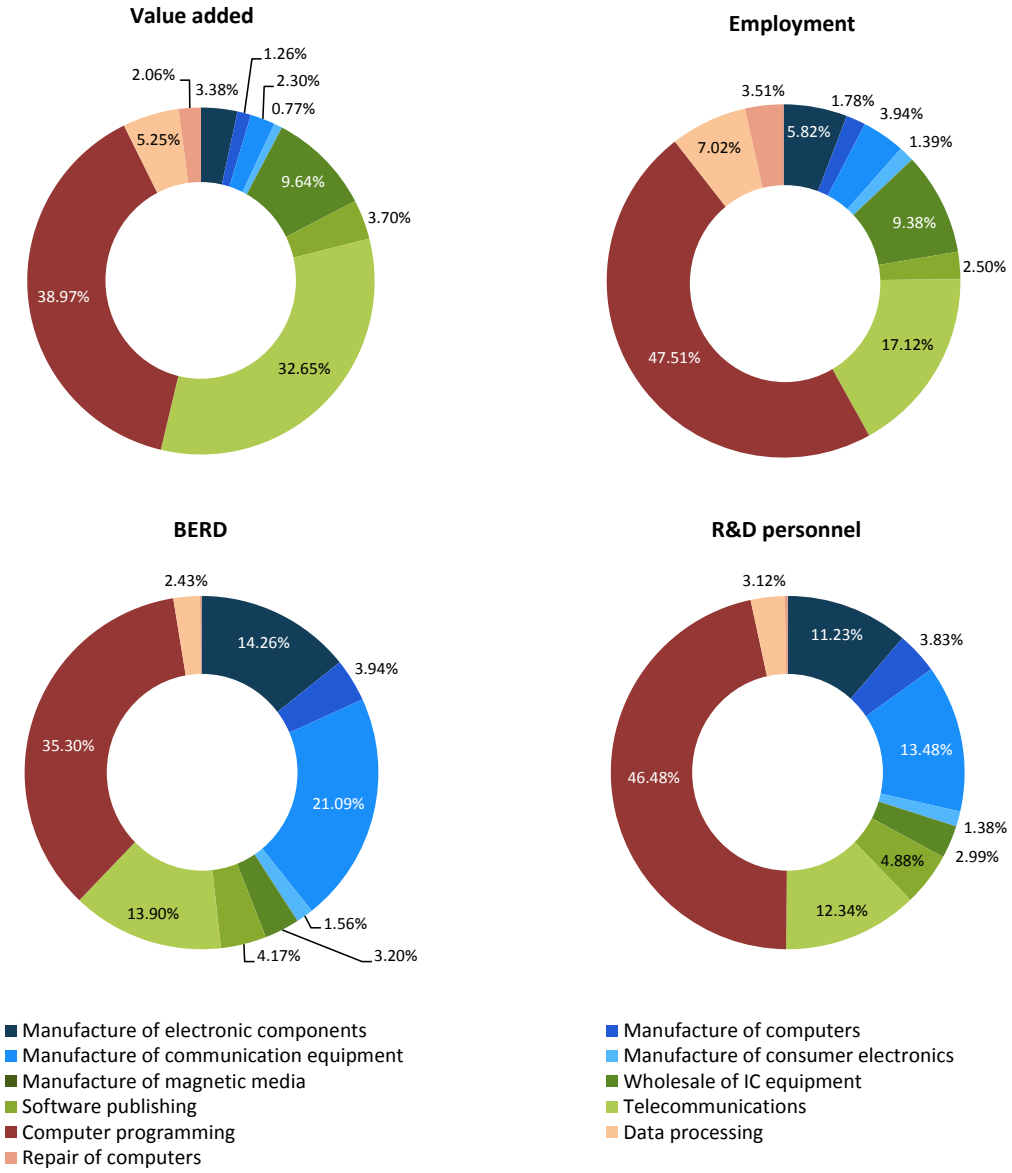
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

2.5 Comparison of indicators and data summary

Figure 30 provides a comparison by ICT sub-sectors of the four main indicators –value added, employment, BERD and R&D personnel– in 2012. The main results of this comparison can be summarised as follows:

- The *Computer programming, consultancy and related activities* sub-sectors consistently scored the highest in all four indicators, with shares between 35.30% and 47.51%. These shares ranged between 34.26% and 47.02% in 2011.
- *Manufacturing of communication equipment* is a highly R&D-intensive sub-sector. While it produced only 2.30% of the total ICT sector VA in 2012 (2.86% in 2011) and employed only 3.94% of the total ICT sector workers (4.14% in 2011), it invested 21.09% of the total ICT sector BERD (23.41% in 2011) and employed 13.48% of ICT sector R&D personnel (14.67% in 2011). Similar characteristics can be seen also in *Manufacture of electronic components and boards.*
- A different situation is observed in the *Telecommunications* sub-sector. On the one hand, this sub-sector produced 32.65% of the total EU ICT sector VA (33.88% in 2011). On the other hand, it represented only half this share in terms of ICT sector employment (17.12%), ICT sector BERD (13.90%) and ICT sector R&D personnel (12.34%) (17.03%, 13.76% and 12.79% in 2011, respectively). A similar pattern was seen in ICT trade industries, with 9.64% of the total ICT sector value added (8.88% in 2011), and only 3.20% of the total ICT sector BERD (2.88% in 2011).

Figure 30: Comparison of value added, employment, BERD, and R&D personnel by ICT sub-sectors (2012)



Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Table 3 shows the data for the main variables analysed in this chapter.

Table 3: Summary table of ICT indicators by sub-sectors. European Union (2012)

NACE Rev. 2	Description	Value added	Employment	BERD	R&D personnel
		(Millions of current EUR)	(thousand persons employed)	(Millions of current EUR)	(thousand full-time equivalent)
261-264, 268	**ICT total manufacturing industries**	**39,917.85**	**801.27**	**11,799.31**	**82.33**
261	Manufacture of electronic components and boards	17,462.4	359.61	4,116.16	30.88
262	Manufacture of computers and peripheral equipment	6,530.44	109.92	1,138.52	10.55
263	Manufacture of communication equipment	11,874.93	243.57	6,087.61	37.07
264	Manufacture of consumer electronics	3,960.7	85.99	451.37	3.79
268	Manufacture of magnetic and optical media	89.39	2.18	5.67	0.04
465, 582, 61, 62, 631, 951	**ICT total services**	**476,579.61**	**5,378.23**	**17,067.93**	**184.48**
465	**ICT trade industries**	**49,809.29**	**579.57**	**924.6**	**8.23**
4651	Wholesale of computers, computer peripheral equipment and software	31,143.65	351.13	-	-
4652	Wholesale of electronic and telecommunications equipment and parts	18,665.64	228.44	-	-
5820, 61, 62, 631, 951	**ICT services industries**	**426,770.31**	**4,798.66**	**16,143.33**	**184.48**
5820	Software publishing	19,100.4	154.3	1,202.76	13.42
61	Telecommunications	168,624.3	1,057.76	4,011.78	33.95
62	Computer programming, consultancy and related activities	201,290.42	2,935.96	10,188.91	127.84
631	Data processing, hosting and related activities; web portals	27,139.57	433.52	700.29	8.58
951	Repair of computers and communication equipment	10,615.63	217.11	39.60	0.70
261-264, 268, 465, 5820, 61, 62, 631, 951	**ICT total**	**516,497.46**	**6,179.5**	**28,867.24**	**275.04**

Note: There is no data available for BERD and R&D personnel in the Statistics on Research and Development (Eurostat) for the ICT trade industries sub-sectors (NACE 4651, NACE 4652).

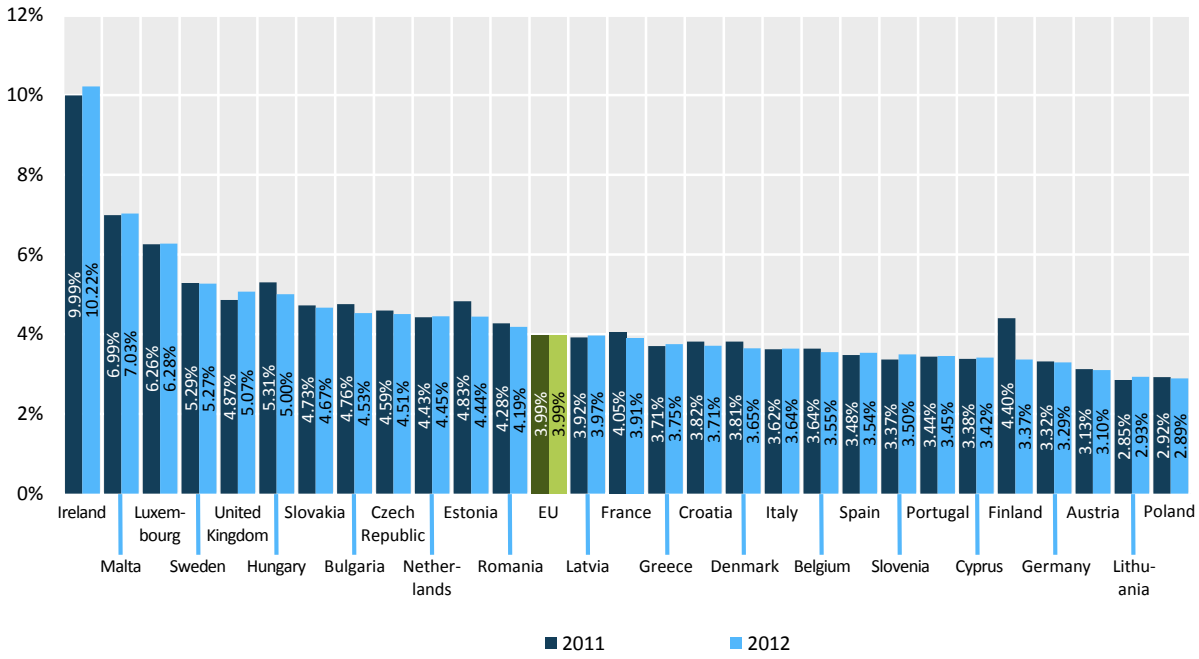
3. Analysis by Member State

3.1 ICT sector value added

ICT sector value added (ICT sector VA) in the EU amounted to 516.50 billion euros in 2012. This represented a share of around 4% of EU GDP, which has remained constant compared to 2011 but below that of 2006 (4.10%).

From the individual country perspective, in 2012 the ICT sector share ranged from 10.22% of total VA for Ireland down to 2.89% for Poland and 2.93% for Lithuania (see Figure 31). Ireland maintained the leading position with a slight increase in the ICT sector share in VA from 9.99% to 10.22%. In 2012, Malta[21] and Luxembourg came next with a share around 3 percentage points lower (7.03% and 6.28%, respectively). Three other countries had shares above or around 5% (Sweden, the United Kingdom and Hungary) and sixteen countries had shares below the EU level (3.99%). Newer Member States as a whole had shares (3.81%) below the EU average in 2012, but it is worth noting that seven of these thirteen countries (Malta, Hungary, Slovakia, Bulgaria, Czech Republic, Estonia and Romania) have ratios of ICT sector VA to GDP above the EU level.

Figure 31: ICT sector VA share of GDP by Member State (2011, 2012)



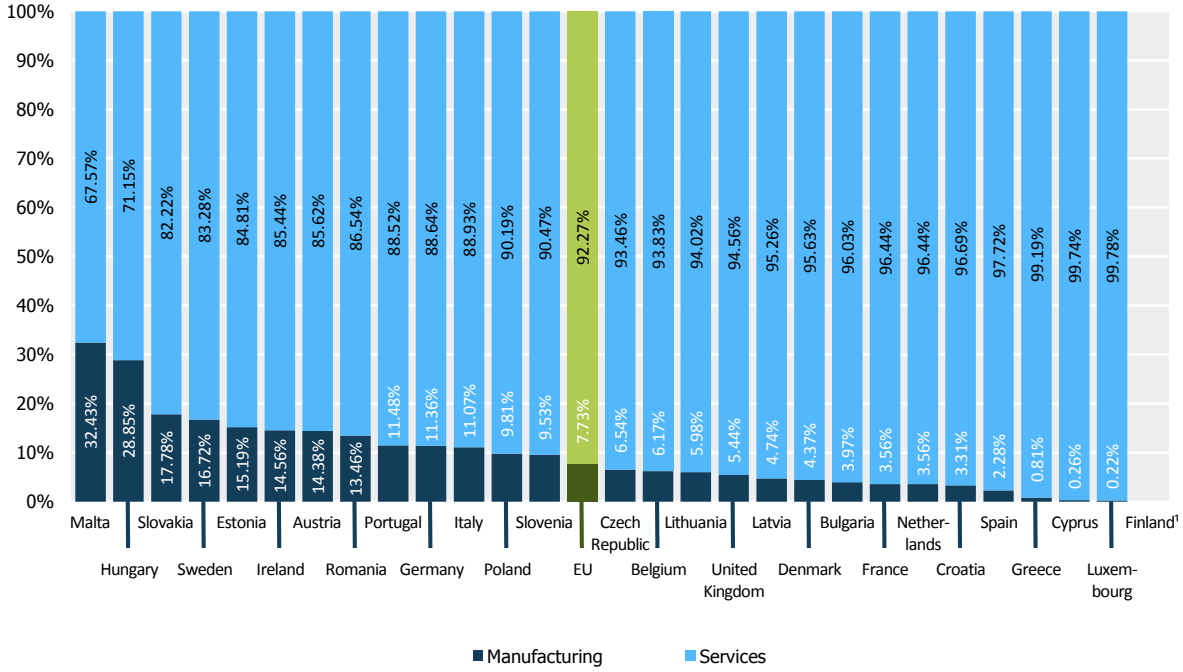
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

In almost all countries the ICT sector VA share of GDP remained fairly stable from 2011 to 2012. Ireland, the United Kingdom, Slovenia, Lithuania and Spain experienced moderate increases between 2011 and 2012, between 0.23 and 0.06 percentage points, whereas Finland and Estonia saw falls of -1.03 and -0.38 percentage points respectively. Here, however, it should be stressed that these falls and increases are relative to GDP, and consequently they depend both on ICT sector VA and on the evolution of GDP in each country. Hence, for instance, the ratios of some countries

[21] Greece, Luxembourg, Croatia and especially Malta lack official data; we therefore recommend taking the results with caution. The missing data not covered by sources mentioned above were estimated using NACE Rev. 1.1 data, correspondence table between NACE Rev. 1.1 and NACE Rev. 2, European averages ICT shares, and turnover/GVA ratio.

like Sweden or Germany declined in 2012 due to a significant increase in GDP (in current terms), which exceeded ICT sector VA growth.

Figure 32: Distribution of VA shares for ICT manufacturing and ICT services by Member State (2012)



[1] Finland is not represented due to the fact that manufacturing value added was negative in 2012. According to Eurostat, this negative value for year 2012 in Finland is due to a few large enterprises logging much higher expenditures in income statement then previous years in the Manufacture of communication equipment sector.

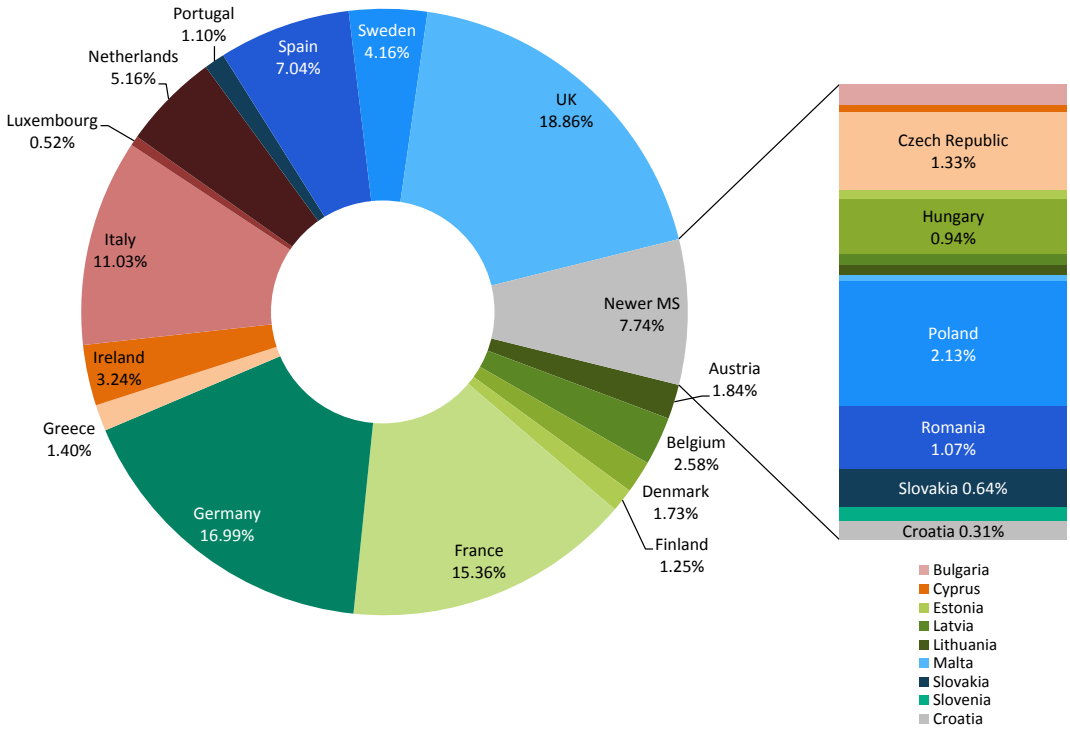
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

At the EU level, ICT services contributed by far the largest share of ICT sector VA (92.27% in 2012), while ICT manufacturing VA contributed only 7.73%. Figure 32 shows the distribution of VA shares for ICT manufacturing and ICT services by country in 2012[22]. The two most ICT manufacturing-oriented countries in the EU are Malta (its ICT manufacturing industries produced 32.43% of total ICT sector VA) and Hungary (28.85%). Other countries with ICT manufacturing sectors that produced relatively high percentages of ICT sector VA were Slovakia (17.78%), Sweden (16.72%), Estonia (15.19%), Ireland (14.56%), Austria (14.38%) and Romania (13.46%). As the countries with larger shares for ICT manufacturing correspond mainly to newer Member States, it is not surprising that their ICT manufacturing sector has a higher share of total VA (12.21%) than the EU average (7.73%).

Clearly, in terms of VA, the ICT sector of every EU Member State is dominated by ICT services. In 2012, the ICT services sectors of ten countries produced over 95% of total ICT sector VA: Luxembourg (99.78%), Cyprus (99.74%), Greece (99.19%), Spain (97.72%), Croatia (96.69%), the Netherlands (96.44%), France (96.44%), Bulgaria (96.03%) and Denmark (95.63%) and Latvia (95.26%).

[22] Finland is not represented due to the fact that manufacturing value added was negative in 2012 in the *Manufacture of communication equipment* sector. According to the official answer Eurostat gave us: "*The negative value for year 2012 is due to few large enterprises logging much higher expenditures in income statement then previous years*".

Figure 33: Distribution of ICT sector VA among Member States (2012)



Note: Newer MS are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 33 provides a comparison of contributions by Member State to EU ICT sector VA in 2012. As expected, the largest EU economies –the United Kingdom (18.86%), Germany (16.99%), France (15.36%), Italy (11.03%) and Spain (7.04%)– contributed the most to EU ICT VA. Together, these five countries produced 69.27% of EU ICT VA in 2012. The Netherlands followed with 5.16%. Overall, the thirteen newer Member States contributed 8.10% to total EU GDP in 2012, a figure slightly higher than their ICT sector contribution of 7.74% to EU ICT sector VA. In 2012, the four EU economies that are most specialised in ICT (Ireland, Malta, Luxembourg and Sweden, see Figure 31) together produced only 8.02% of the EU ICT sector VA, i.e., less than the share of Italy (11.03%) and around one percentage point more than the share of Spain.

3.2 ICT sector employment and ICT sector labour productivity

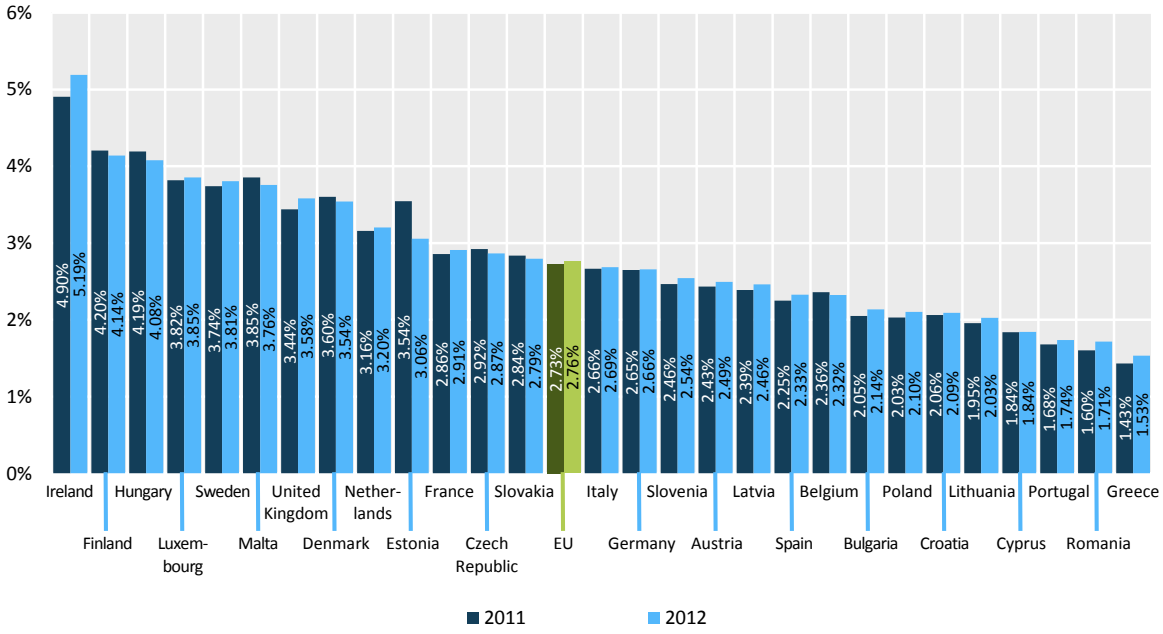
3.2.1 ICT sector employment

In 2012, 6.18 million people worked in the EU ICT sector, representing 2.76% of employment in the EU. This percentage was slightly lower in 2011 (2.73%), and much lower in 2006 (2.62%), meaning that other non-ICT sectors were more affected by the crisis.

Figure 34 compares the ICT sector employment shares of total employment by Member State (based on head counts). As with ICT sector value added in GDP, the leading country in 2011 and 2012 was Ireland with a share of 5.19% in 2012 (4.90% in 2011). Apart from Ireland only Finland (4.14%) and Hungary (4.08%) had shares over 4% in 2012 (down from 4.20% and 4.19%,

respectively, in 2011). At the other end of the scale, four countries –Cyprus, Portugal[23], Romania and Greece– had shares below 2% in 2012.

Figure 34: ICT sector employment share of total employment by Member State (% of head counts; 2011, 2012)



Source: Eurostat, elaborated by Ivie and JRC-IPTS.

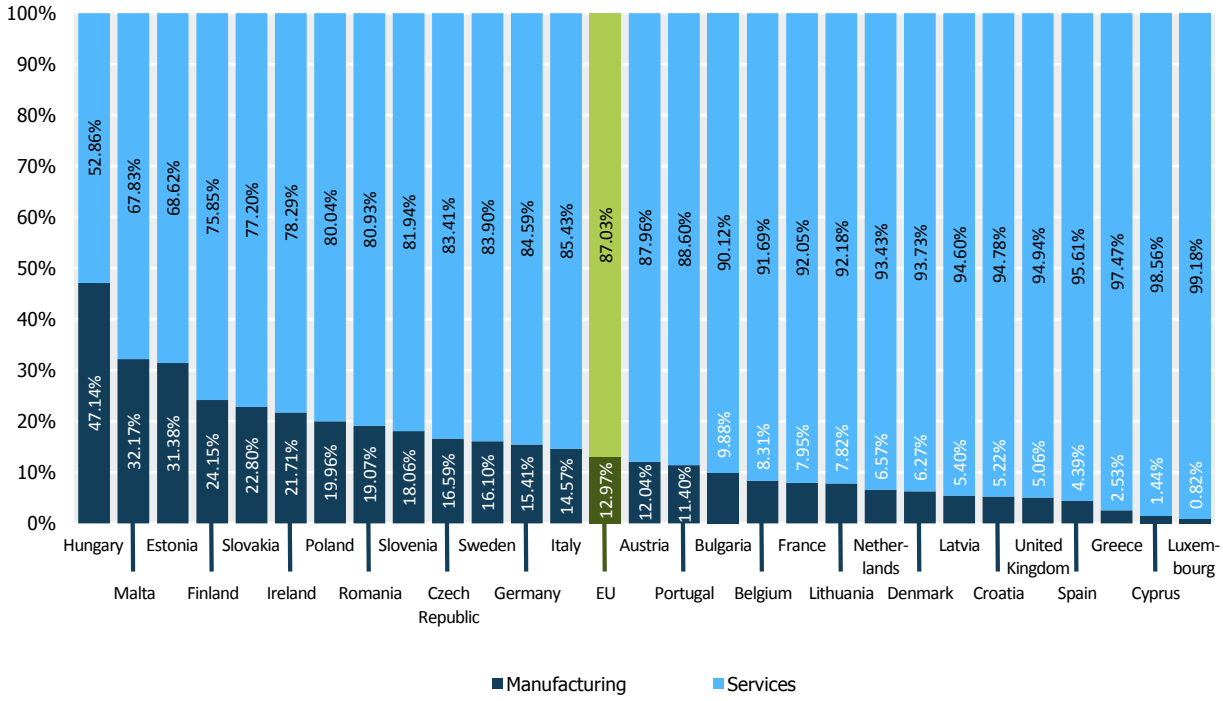
Between 2011 and 2012, the EU ICT sector gained around 59.4 thousand workers. The largest increases were in the United Kingdom with around 53.98 thousand workers (this figure represented 91% of jobs created in the EU ICT sector between 2011 and 2012), Germany (around 16.28 thousand workers), France (around 13.70 thousand workers), Romania (12.41 thousand workers) and Poland (around 11.70 thousand workers). In general, 15 out of 28 European countries generated employment in the EU ICT sector, but it was lost in the other thirteen. The countries where ICT sector employment fell in absolute terms in 2012 were: Hungary (4.48 thousand workers), Spain (3.65 thousand), Estonia (2.47 thousand), the Czech Republic (2.30 thousand), Denmark (1.96 thousand), Finland (1.52 thousand), Belgium (1.31 thousand) and Greece (1.15 thousand).

At the EU level in 2012, ICT manufacturing employed 12.97% of the ICT sector workforce. There is considerable variation among Member States in the distribution of labour between the two ICT sub-sectors (manufacturing and services). A large number of newer EU Member States have become important ICT manufacturing countries, and have relatively high employment in ICT manufacturing (see Figure 35). This was the case for Hungary (47.14% of ICT sector employment in manufacturing), Malta (32.17%), Estonia (31.38%), Slovakia (22.80%), Poland (19.96%), Romania (19.07%), Slovenia (18.06%) and the Czech Republic (16.59%). Other EU countries with a relatively high share of ICT manufacturing employment were Finland (24.15%) and Ireland (21.71%). On the other hand, countries with the biggest share of ICT services employment in 2012 were Luxembourg (99.18%), Cyprus (98.56%), Greece (97.47%), Spain (95.61%), the United Kingdom (94.94%) and Croatia (94.78%).

[23] Recall that Greece, Luxembourg, Croatia and especially Malta lack official data; we therefore recommend taking the results with caution. The missing data for ICT sector employment were estimated using some alternative methods like NACE Rev. 1.1 data, correspondence table between NACE Rev. 1.1 and NACE Rev. 2, and European average ICT sectors shares.

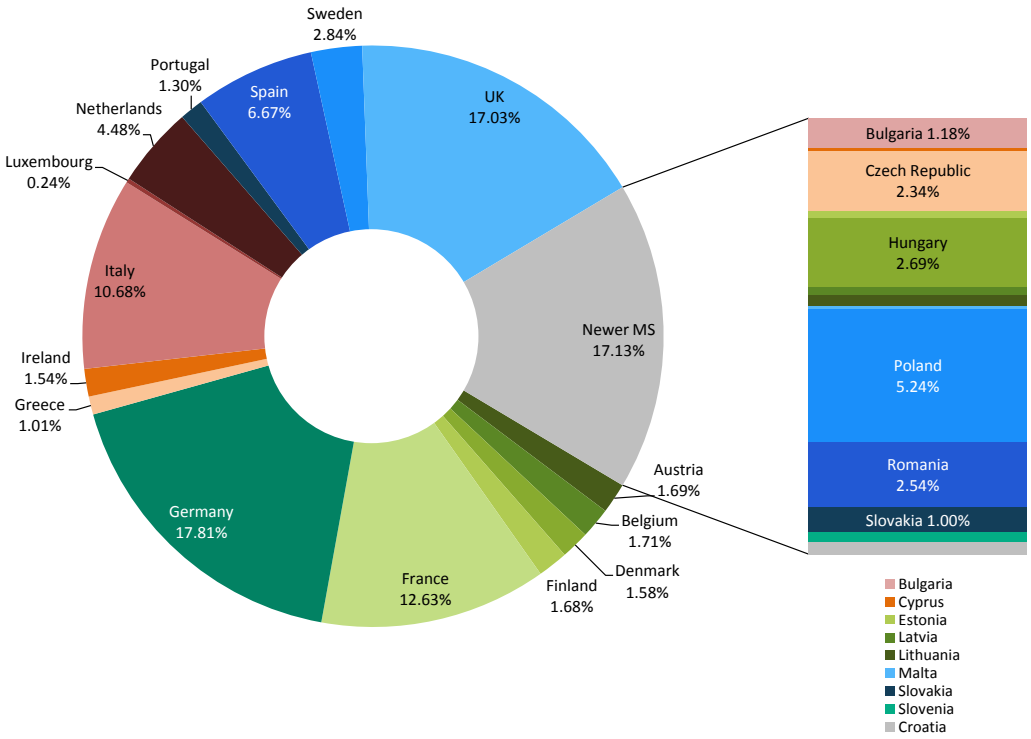
Figure 36 compares Member State contributions to EU ICT sector employment in 2012. EU ICT sector employment was concentrated in the five largest EU economies: Germany (17.81%), the UK (17.03%), France (12.63%), Italy (10.68%) and Spain (6.67%) represented 64.82% of EU ICT employment in 2012. Other EU countries with fairly high shares of ICT sector employment relative to their economic size were Poland (5.24%) and the Netherlands (4.48%). Sweden was next with 2.84%, followed by three newer Member States with high contributions relative to their economic size: Hungary (2.69%), Romania (2.54%) and the Czech Republic (2.34%). Overall, newer Member States contributed 17.13% to ICT sector employment relatively high compared with their economic size in terms of GDP which is only 8.10%.

Figure 35: Distribution of ICT sector employment shares between ICT manufacturing and ICT services by Member State (% of head counts, 2012)



Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 36: Distribution of ICT sector employment among Member States (head counts, 2012)



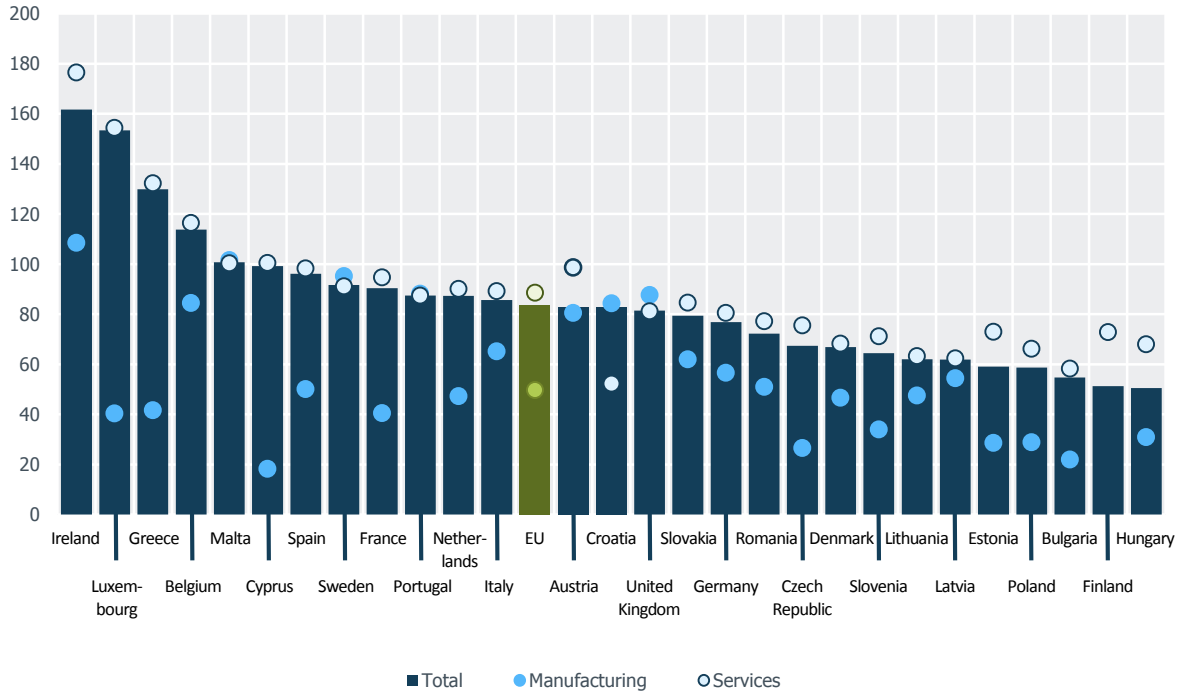
Note: Newer MS are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

3.2.2 ICT sector labour productivity

Figure 37 shows that the EU ICT sector labour productivity level in 2012 was around 83.6 thousand current euros PPS (Purchasing Power Standard) per person[24]. Ireland had the highest level (161.71), followed by Luxembourg (153.46), then Greece (129.91) and Belgium (113.79). All the newer Member States (except Malta, Cyprus and to a lesser extent Croatia, Slovakia, Romania and the Czech Republic) had the lowest levels of ICT sector labour productivity. Among the countries with the low level of labour productivity is Finland due to the negative value added in manufacturing mentioned earlier. It is also interesting to note that ICT services in almost all countries (23 out of 28) had higher labour productivity than the total and, therefore, than ICT manufacturing. The only exceptions were Croatia, United Kingdom, Sweden and to a lesser extent Malta and Portugal.

[24] The bright blue bubbles in Figure 3-7 indicate the value of ICT sector labour productivity in the manufacturing sector whereas the light blue bubbles indicate the value of ICT sector labour productivity in the services sector.

Figure 37: ICT sector labour productivity by Member State (thousands of EUR PPS [Purchasing Power Standard] per person, 2012)



Note: Data are not calculated for Finland for ICT manufacturing in 2012.
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

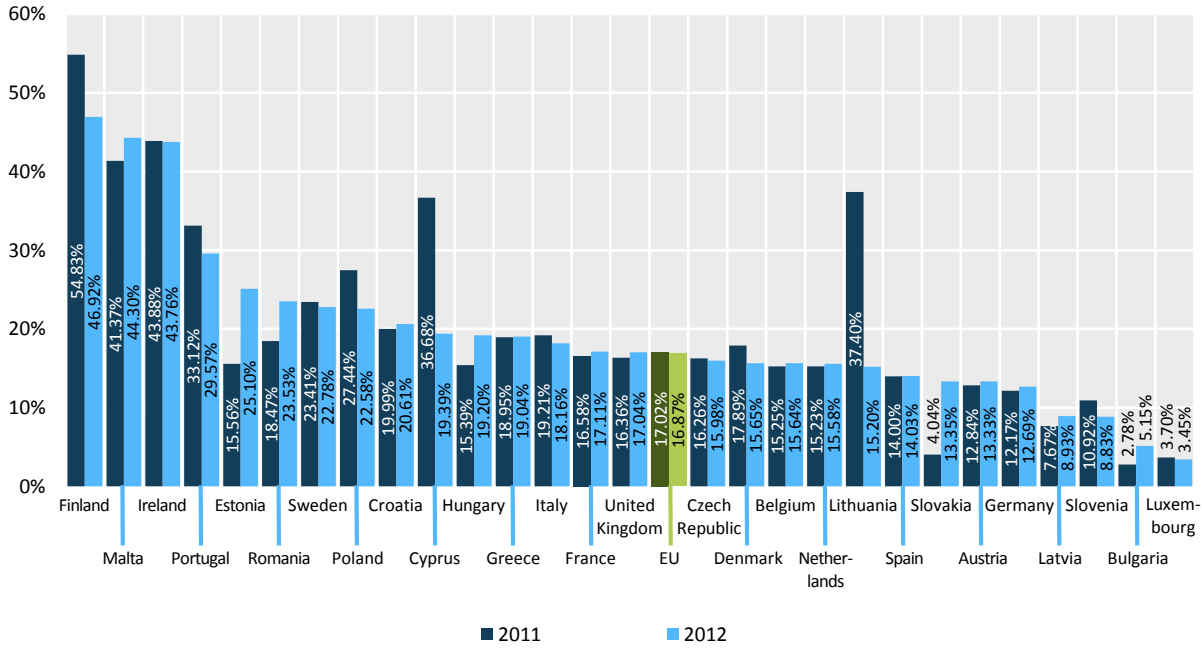
3.3 ICT sector business enterprise R&D (BERD) expenditure

In 2012, EU ICT sector Business Enterprise R&D (ICT sector BERD) Expenditure amounted to 28.87 billion euros, 3.42% more than in 2011 in nominal terms (27.91 billion euros). This represented 16.87% of the total EU BERD in 2012, a slightly lower percentage than 2011 (17.02%).

Figure 38 presents ICT sector BERD shares of total BERD by Member State. Of total BERD in the ICT sector in 2012, Finland spent 46.92%, 7.9 percentage points less than in 2011 and reducing significantly the differences with the rest of countries with highest shares: Malta (44.30%) and Ireland (43.76%). Portugal, Estonia, Romania, Sweden, Poland and Croatia followed with shares between 30% and 20% of total BERD. In 2012, the countries with by far the lowest share of ICT sector BERD in total BERD were Bulgaria (5.15%) and Luxembourg (3.42%).

In 2012, 16 of the 28 countries had a higher ICT sector BERD share of total BERD than in 2011. This group consisted of eight countries belonging to the former EU15 (the United Kingdom, France, Germany, Austria, Belgium, Netherlands, Greece and Spain) and eight countries that entered the EU in recent years (Estonia, Slovakia, Romania, Hungary, Malta, Bulgaria, Latvia and Croatia). The largest increase took place in Estonia, from 15.56% in 2011 to 25.10% in 2012, and Slovakia, from 4.04% to 13.35%, whereas the sharpest drop occurred in Lithuania, from 37.40% in 2011 to 15.20% in 2012 (mainly due to the fall in the *Telecommunications* sub-sector), and Cyprus, from 36.68% to 19.39% (essentially due to the shrinking *Computer program* sub-sector).

Figure 38: ICT sector BERD share of total BERD by Member State (2011, 2012)



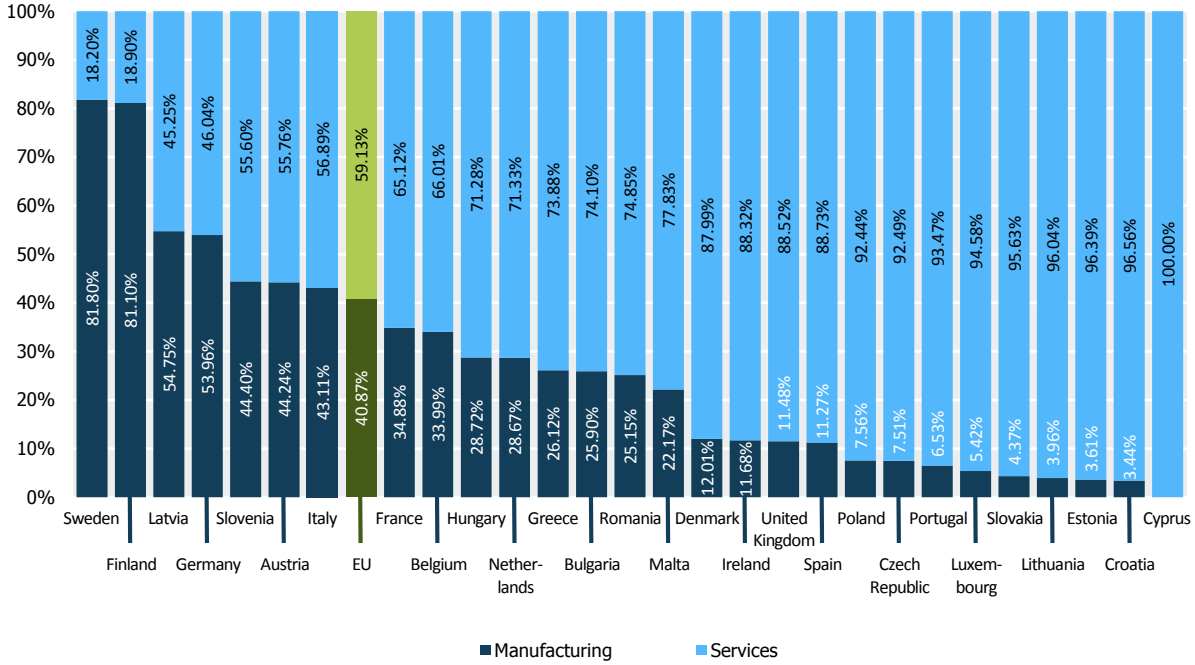
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

At EU level in 2012, ICT sector BERD (28.87 billion euros) was divided between manufacturing (11.80 billion euros, 40.87% of total ICT sector) and services (17.07 billion euros, 59.13% of total), with a higher presence of ICT services whose weight in 2006 barely reached 47%.

Figure 39 shows the distribution of ICT sector BERD between ICT manufacturing and ICT services by Member State in 2012. Only four EU countries recorded more BERD in ICT manufacturing than in ICT services. Sweden led with a share of 81.80%, followed by Finland (81.10%). The remaining two countries in this group were Latvia (54.75%) and Germany (53.96%). On the other hand, shares of ICT sector BERD in services were especially important in Cyprus (100.00%), Croatia (96.56%), Estonia (96.39%), Lithuania (96.04%) and Slovakia (95.63%)[25].

[25] Greece and Luxembourg lack official data; we therefore recommend taking the results with caution. The missing data were estimated using alternative methods like NACE Rev. 1.1 data and correspondence table between NACE rev. 2 and NACE Rev 1.1 or percentage structure of turnover.

Figure 39: Distribution of ICT sector BERD between ICT manufacturing and ICT services by Member State (2012)

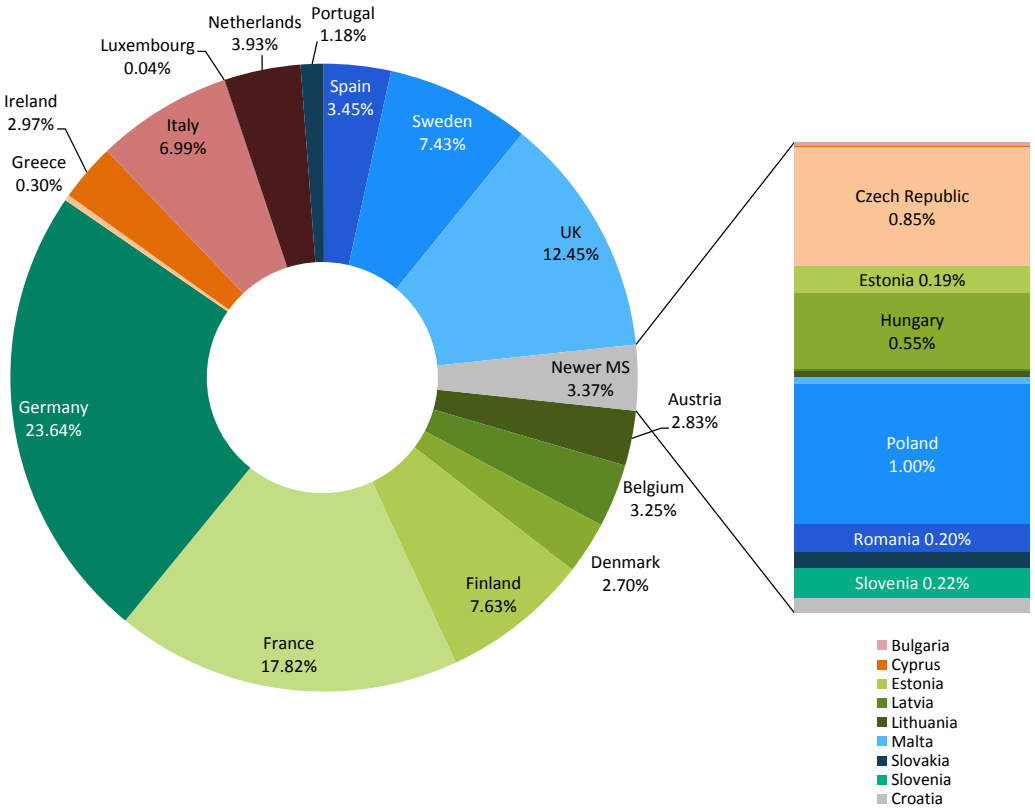


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

In 2012, the largest contributors to EU ICT sector BERD (Figure 40) were Germany (23.64%) and France (17.82%). These two countries alone accounted for 41.46% of total EU ICT sector BERD. They were followed, albeit at a certain distance, by the UK (12.45%), Finland (7.63%), Sweden (7.43%) and Italy (6.99%). These six countries together spent 75.97% of total EU ICT sector BERD in 2012. On the other hand, in the case of BERD, the newer Member States had a smaller contribution to EU aggregate (3.37%) when compared with ICT sector VA (7.74%) and employment (17.13%), as these countries have benefitted from the relocation process in the production but not in the R&D activities[26].

[26] See *Internationalisation of business investments in R&D*, Innovation Union Competitiveness Papers, Issue 2013/1. European Commission. 2013.

Figure 40: Distribution of ICT sector BERD among Member States (2012)

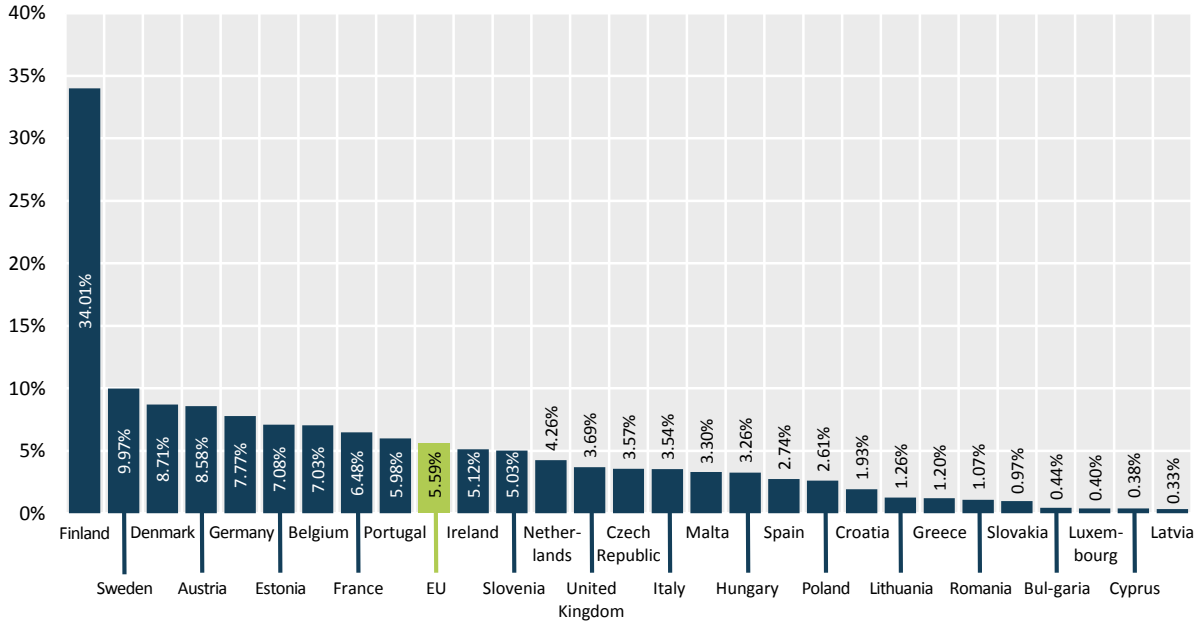


Note: Newer MS are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

ICT sector BERD intensity (defined as the ratio of ICT sector BERD to ICT sector VA) in the EU in 2012 amounted to 5.59%. Finland, despite being a small economy in terms of GDP and even in terms of absolute ICT sector VA, had by far the highest ICT sector BERD intensity with 34.01% (see Figure 41). Sweden, Denmark and Austria also had relatively high ICT sector BERD intensities, but only less than a third of Finland's. In the same year, ICT sector BERD intensity in Sweden amounted to 9.97%, in Denmark, 8.71%, and in Austria, 8.58%. Five other countries had ICT sector BERD intensities above the EU level: Germany (7.77%), Estonia (7.08%), Belgium (7.03%), France (6.48%) and Portugal (5.98%). Some of the newer Member States –Latvia (0.33%), Cyprus (0.38%) and Bulgaria (0.44%) – together with Luxembourg (0.40%), had the lowest levels.

ICT sector BERD intensity increased slightly in the EU as a whole between 2011 and 2012 (from 5.51% to 5.59%). The countries where it increased include Estonia, Hungary, Austria, Slovakia, Finland, Belgium, Germany, France, Malta, Poland, the Czech Republic, the Netherlands, Romania, Bulgaria, Croatia and Ireland. Greece and Latvia remained stable, whereas Sweden, Cyprus, Denmark, Portugal, Slovenia and Lithuania experienced the highest drops of between 0.35 and 1.87 percentage points.

Figure 41: ICT sector BERD intensity (ICT sector BERD/ICT sector VA) by Member State (2012)



Source: Eurostat, elaborated by Ivie and JRC-IPTS.

3.4 Public funding of ICT R&D

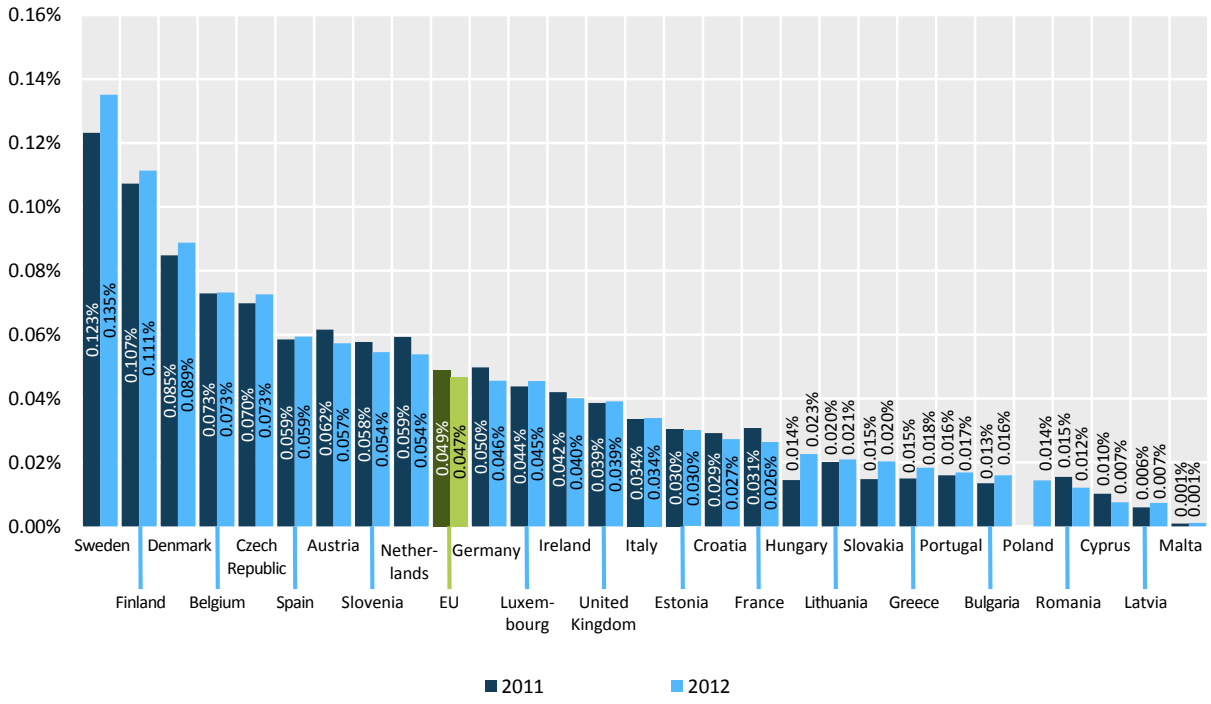
In 2012, estimated public ICT R&D funding in the EU amounted to 6.07 billion euros –6.68% of the total EU public funding of R&D. In this analysis, public ICT R&D funding is estimated[27] under the assumption that the share of ICT R&D expenditures in GBAORD is similar to the share of ICT R&D labour costs (from total R&D labour costs).

Figure 42 shows public ICT R&D funding intensity (defined as public funding of ICT R&D / GDP) in EU Member States in 2011 and 2012. In both years, Sweden led (with 0.135% in 2012), followed by Finland (0.111%) and Denmark (0.089%). Public ICT R&D funding intensity increased in 14 of the 28 European countries between 2011 and 2012 with the greatest increases seen in Sweden, Hungary, Slovakia, Finland and Denmark. The UK, Italy, Belgium, Malta and Estonia remained stable, while the largest decreases occurred in Germany, Austria, France and the Netherlands.

It is also interesting to note that in 2012, nine countries were above the EU level, namely Sweden, Finland, Denmark, Belgium, the Czech Republic, Spain, Austria, Slovenia and the Netherlands. However, the relative positions of four of them changed. A remarkable case was Spain, which went from the eighth to the sixth position, not as a result of an increase in ICT GBOARD, but due to a fall in its GDP in 2012.

[27] Stančík, J., & Rohman, I. K. (2014). Public ICT R&D funding in the European Union. JRC Scientific and Policy Report. Available at: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC92883/jrc92883.pdf

Figure 42: Share of ICT GBAORD in GDP by Member State (2011, 2012)

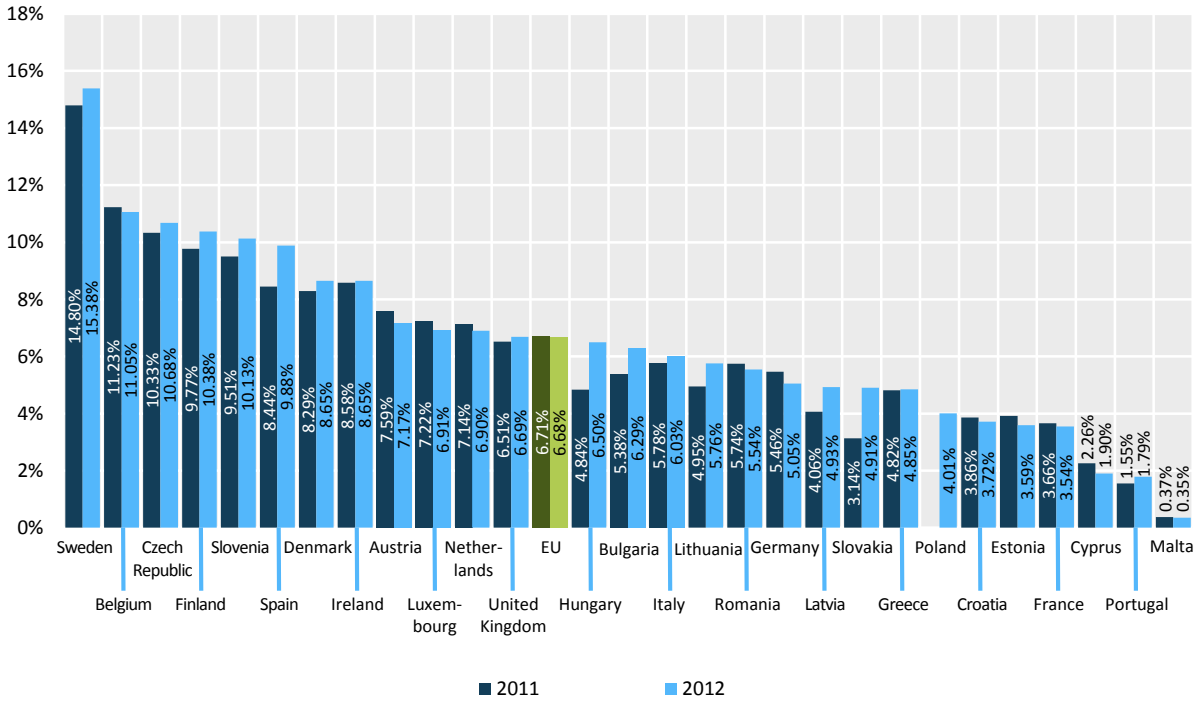


Note: Data are not available for Poland for the period 2009-2011.
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

As noted in the introduction to this subsection, another interesting figure that measures the intensity of ICT GBAORD is the ratio between the estimated ICT GBAORD and total GBAORD (Figure 43). In this case, Sweden ranked first again for both years 2011 and 2012, with 15.38% in 2012, followed by Belgium (11.05%), the Czech Republic (10.68%), Finland (10.38%) and Slovenia (10.13%). The shares of 16 of the 28 European countries increased between 2011 and 2012, with the greatest increases in some of the New MS (Slovakia, Hungary, Bulgaria, Latvia, Lithuania and Slovakia), in addition to Spain, Finland, Sweden and Denmark. By contrast Austria and Germany suffered the greatest falls.

It can be seen that countries with high ICT GBAORD shares in total GBAORD also have high ICT GBAORD shares in GDP and the contrary happens also in the opposite direction. The least ICT GBAORD intensive countries in 2012 were Malta, Portugal, Cyprus, France, Estonia and Croatia, all below 4%. These countries also devoted less or around 0.03% of their GDP to ICT GBAORD.

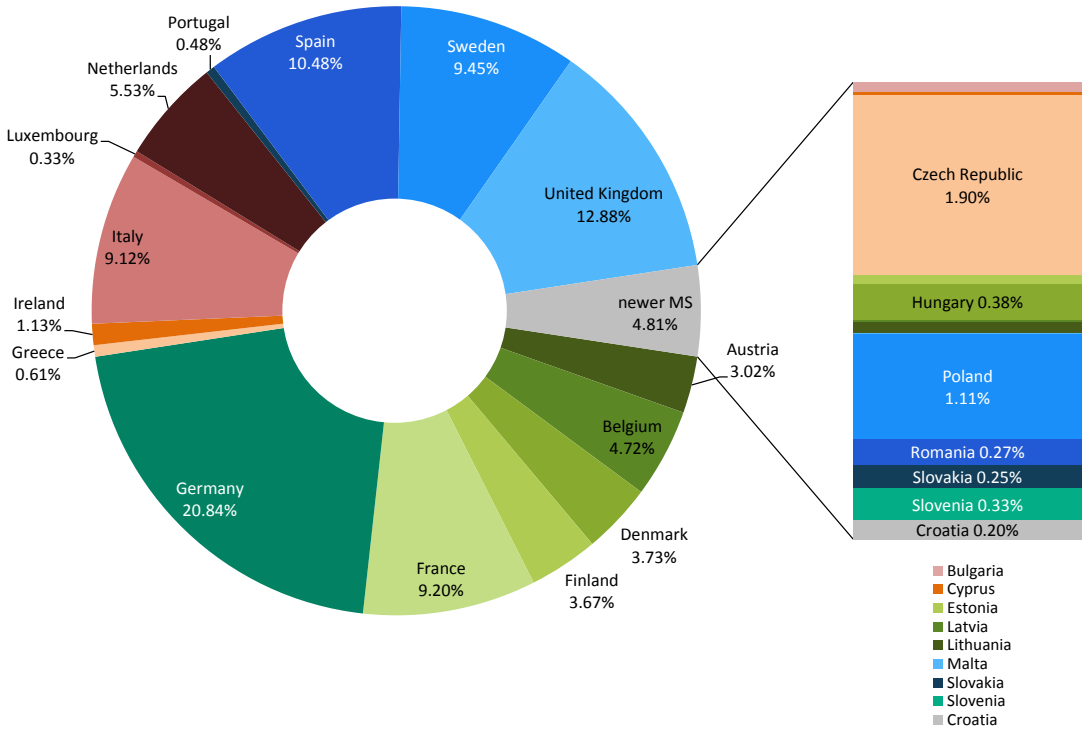
Figure 43: Share of ICT GBAORD in total GBAORD by Member State (2011, 2012)



Note: Data not available for Poland for the period 2009-2011.
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

In 2012, the EU's five largest economies –Germany (20.84%), the UK (12.88%), Spain (10.48%), Sweden (9.45%), France (9.20%) and Italy (9.12%) – plus Sweden provided the largest contributions to total public funding of ICT R&D in the EU. These six countries together accounted for 71.97% of total ICT GBAORD in the EU. Next came the Netherlands (5.53%), Belgium (4.72%), Denmark (3.73%), Finland (3.67%) and Austria (3.02%). The newer Member States together accounted for only 4.81% of the total ICT GBAORD, a contribution that was significantly below their economic weight (8.10% of the total EU GDP).

Figure 44: Distribution of ICT GBAORD among Member States (2012)



Note: New MS are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

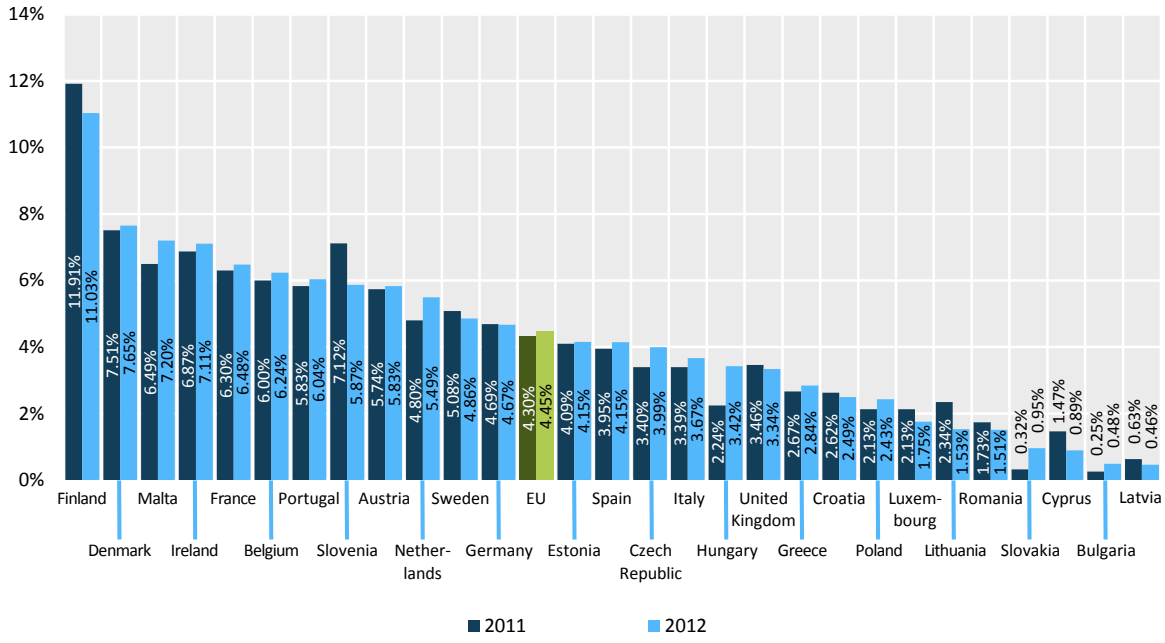
3.5 ICT sector R&D personnel

ICT sector R&D personnel (including both researchers and R&D supporting staff) made up 4.45% of total ICT sector employment in the EU in 2012. This share increased considerably between 2011 and 2012 (4.30% in 2011).

Figure 45 presents ICT sector R&D personnel shares of total ICT sector employment by Member State. During the analysed period (2011–2012), Finland led the EU Member States with a share of 11.91% in 2011 and 11.03% in 2012. At a distance of more than 3 percentage points was Denmark with a 7.65% share in 2012, followed by Malta (7.20%) and Ireland (7.11%). Eight other countries scored above the EU level. The lowest ranking countries were mostly newer Member States (Lithuania (1.53%), Romania (1.51%), Slovakia (0.95%), Cyprus (0.89%), Bulgaria (0.48%) and Latvia (0.46%)), but also several important ICT R&D players like Italy (3.67%), the United Kingdom (3.34%), Greece (2.84%)[28] and Luxembourg (1.75%).

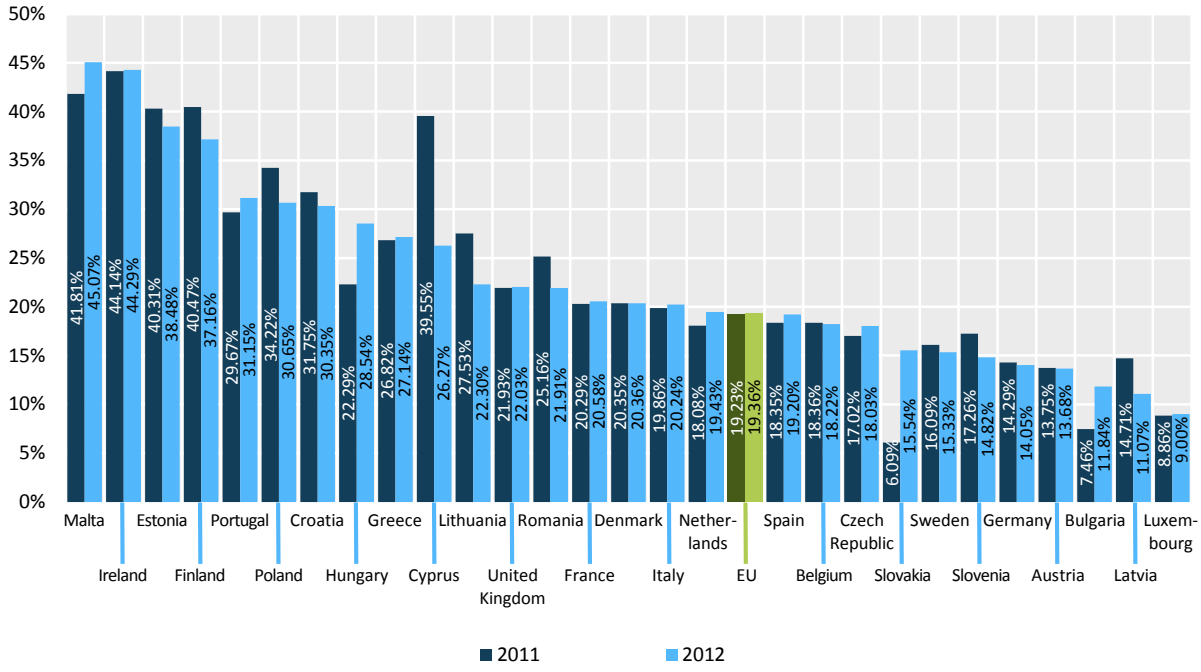
[28] Again, Greece and Luxembourg lack official data also for this variable; we therefore recommend taking the results with caution. The missing data were estimated using alternative methods like NACE Rev .1.1 data and correspondence table between NACE rev. 2 and NACE Rev 1.1 or percentage structure of Highly Qualified employment.

Figure 45: ICT sector R&D personnel share of total ICT sector employment by Member State (based on FTE; 2011, 2012)



Source: Eurostat, elaborated by Ivie and JRC-IPTS.

Figure 46: ICT sector R&D personnel share of total R&D personnel by Member State (based on FTE; 2011, 2012)

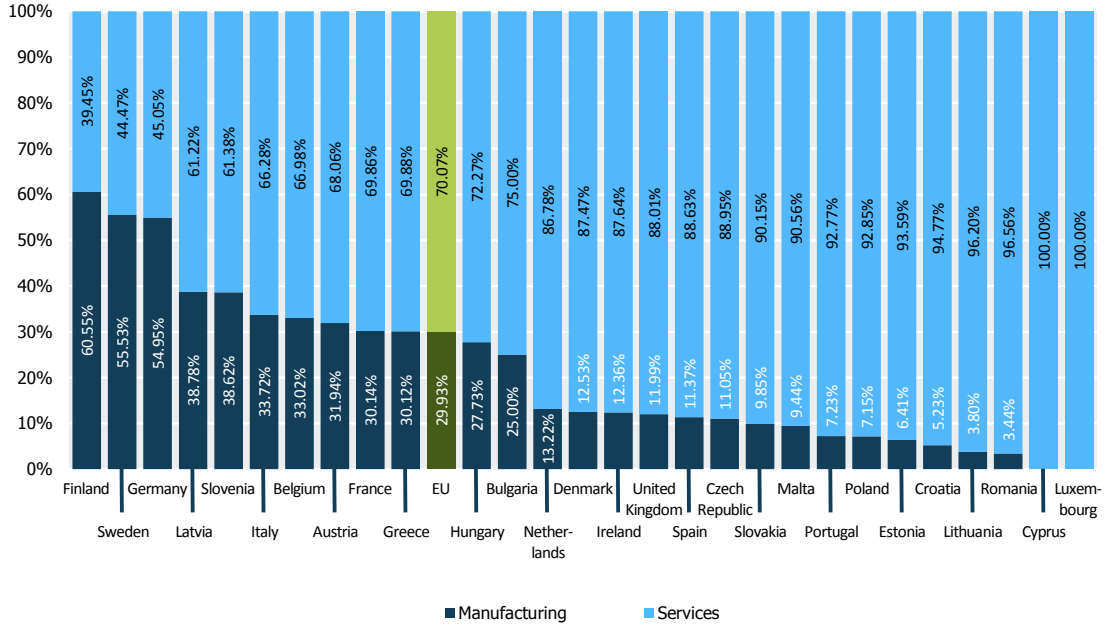


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

In terms of ICT sector R&D personnel over total R&D personnel (Figure 46), Malta, Ireland, Estonia and Finland are the leading countries with a share of more than 35% in 2012. Thirteen other countries scored above the EU level, many of which are newer Member States. This is the case of Poland (30.65%), Croatia (30.35%), Hungary (28.54%), Cyprus (26.27%), Lithuania (22.30%) and Romania (21.91%). The other countries above EU level are Portugal (31.15%), Greece (27.14%), the UK (22.03%), France (20.58%), Denmark (20.36%), Italia (20.24%) and the Netherlands (19.43%). On the other hand, Bulgaria, Latvia and Luxembourg had shares below 12%[29].

Figure 47 provides a comparison of the distribution of ICT sector R&D personnel between manufacturing and services by Member State. At the EU level more than two thirds (70.07%) of ICT sector R&D jobs were in services in 2012, and 25 EU countries had more ICT sector R&D jobs in services than in manufacturing. The highest share of services employment in total R&D employment was observed in Slovakia, Malta, Portugal, Poland, Estonia, Croatia, Lithuania, Romania, Cyprus and Luxembourg, all of them over 90% in the same year. At the other extreme are countries like Finland, Sweden and Germany, where the manufacturing sector plays a major role in terms of ICT sector R&D personnel. In all three of these countries more than 50% of their ICT sector R&D employees were working in ICT manufacturing in 2012. In Finland, this ratio was as high as 60.55%.

Figure 47: Distribution of ICT sector R&D personnel between ICT manufacturing and ICT services by Member State (based on FTE, 2012)

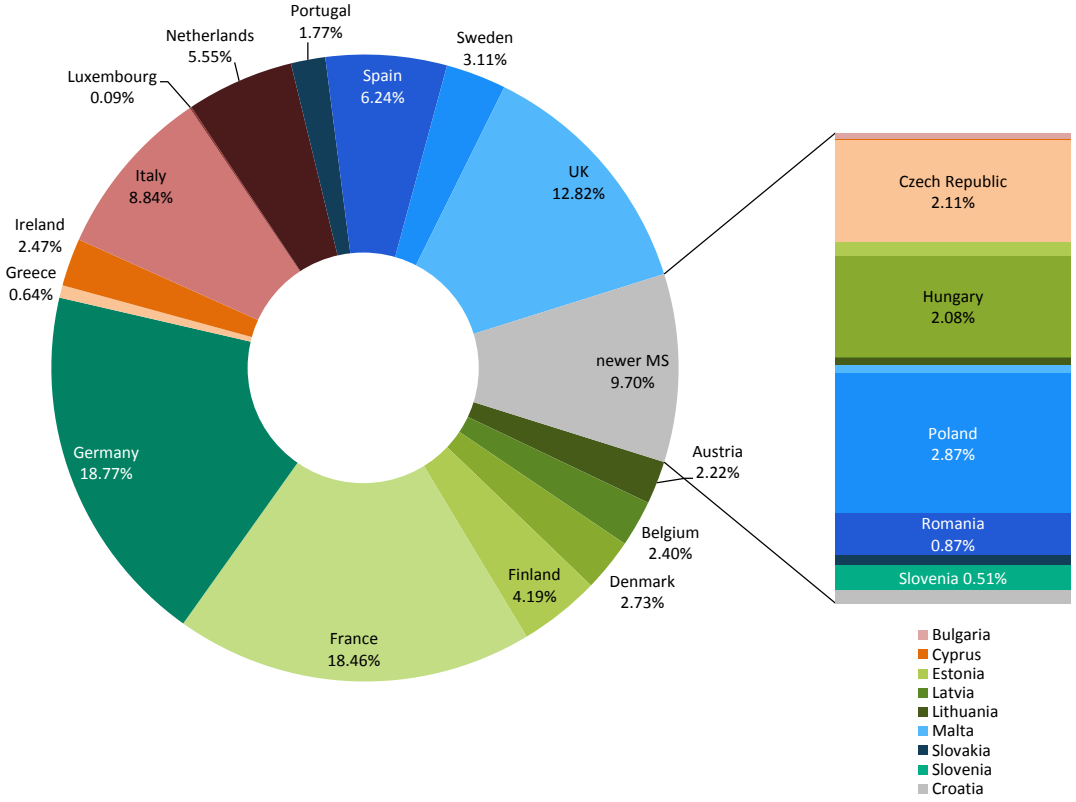


Source: Eurostat, elaborated by Ivie and JRC-IPTS.

[29] Again, Greece and Luxembourg lack official data also for this variable; their results should therefore be taken with caution. The missing data were estimated using alternative methods like NACE Rev .1.1 data and correspondence table between NACE rev. 2 and NACE Rev 1.1 or percentage structure of Highly Qualified employment.

Figure 48 shows the distribution of ICT sector R&D personnel among Member States. As with other indicators, the largest EU economies took the lead in 2012. Germany (18.77%) and France (18.46%) led the field, followed by the UK (12.82%) and Italy (8.84%). These four countries together employed 58.89% of ICT sector R&D workers in the EU in 2012. What is also remarkable is Finland's relatively high share (4.19%). Among the main contributors, Spain –which employed almost 6.24% of ICT sector R&D employees– should also be mentioned, followed by the Netherlands (5.55%). It is also of interest that Germany, France and the UK, individually, employed more ICT sector R&D workers than the whole group of thirteen newer Member States (9.70%). In this group, Poland (2.87%), the Czech Republic (2.11%) and Hungary (2.08%) had the highest shares.

Figure 48: Distribution of ICT sector R&D personnel among Member States (based on FTE, 2012)

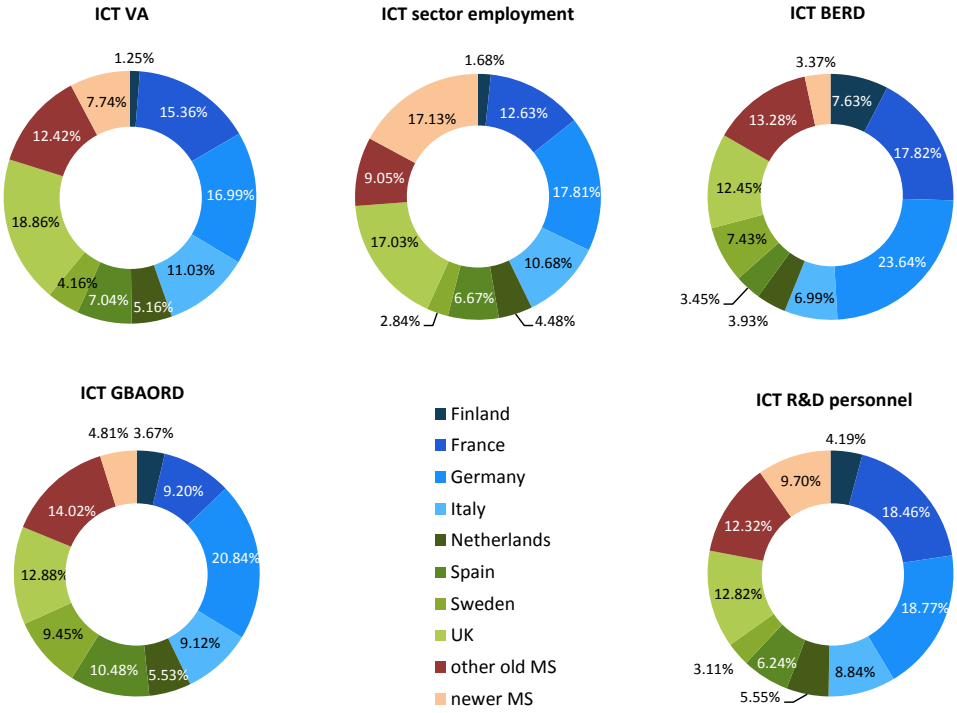


Note: New MS are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

3.6 Comparison of indicators and data summary

In this section, all five previously analysed indicators are compared in terms of Member State contributions (see Figure 49). Overall, due to the importance of their economies or to their particularly large ICT sector or strong ICT sector BERD intensities, only eight countries play significant roles in both ICT sector VA generation and ICT sector BERD in the EU according to this particular selection of indicators. This does not mean that important ICT activities do not take place in other Member States, but that a size effect makes these particular Member States stand out. A finer regional analysis would most certainly identify important ICT regions in other Member States.

Figure 49: Comparison of ICT sector VA, ICT sector employment, ICT sector BERD, ICT GBAORD and ICT sector R&D personnel by Member State (2012)



Note: Newer MS are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia. Other old MS comprise Austria, Belgium, Denmark, Greece, Ireland, Luxembourg and Portugal.

Source: Eurostat, elaborated by Ivie and JRC-IPTS.

These eight countries are analysed individually in this section. The other countries are grouped into *older MS* and *newer MS* categories.

Unsurprisingly, the fact that emerges most clearly is the dominance of four major economies (France, Germany, Italy and the United Kingdom) in all five indicators. There are some exceptions (e.g., Finland in ICT sector BERD, ICT GBAORD and in ICT R&D personnel), but these four countries together systematically contributed around 60% in all indicators except for ICT GBAORD (52.04%). This pattern was the same in 2011, with a 53.49% share in ICT GBAORD.

Other interesting facts (all related to 2012) can be summarised as follows:

– Finland produced 1.25% of total EU ICT sector VA and employed 1.68% of the total EU ICT sector employees, but invested 7.63% of total EU ICT sector BERD (1.64%, 1.74% and 9.92% in 2011, respectively). Sweden was in a similar position, producing 4.16% and employing

2.84%, but investing 7.43% in ICT sector BERD and 9.45% in ICT GBAORD (4.02%, 2.82%, 7.54% and 8.12% in 2011, respectively).

- The thirteen newer Member States together produced 7.74% of total EU ICT sector VA (7.96% in 2011). To achieve this, they needed 3.37% of total EU ICT sector BERD (2.95% in 2011) but employed 17.13% of the total EU ICT sector workforce (17.17% in 2011) and 9.70% of EU ICT sector R&D personnel (8.73% in 2011).
- In terms of public funding of ICT R&D, it is interesting to note the case of Spain, with a share of 7.04% in EU ICT sector VA and 3.45% in EU ICT sector BERD, but with an ICT public funding share of 10.48% of EU ICT GBAORD (7.17%, 3.71% and 10.48% in 2011, respectively). On the other hand, France showed a relatively lower share in EU ICT GBAORD as compared with the rest of indicators, always between 12.63% (share of EU ICT employment; 12.64% in 2011) and 18.46% (share of EU R&D personnel; 18.42% in 2011), but with an ICT GBAORD share of 9.20% (10.54% in 2011).
- The contribution of Germany was very consistent across all four indicators (always between 16.99% and 23.64%, and between 17.06% and 22.27% in 2011). Similarly consistent patterns can be seen in Italy (always between 6.99% and 11.03%, and between 7.45% and 11.27% in 2011), the United Kingdom (always between 12.45% and 18.86%, and between 11.75% and 16.98% in 2011) and in the group of *other older* Member States (always between 9.05% and 14.02%, and between 9.15% and 13.73% in 2011).

Table 4 summarises the main information presented in this chapter.

Table 4: Summary table of ICT indicators by European country. European Union (2012)

ICT total:	Value added	Employment	BERD	ICT GBAORD	R&D personnel
	(Millions of current EUR)	(1000 persons employed)	(Millions of current EUR)	(Millions of current EUR)	(1000 Full-Time Equivalent)
Finland	6,477.66	104.40	2,202.93	214.26	11.52
France	79,398.26	783.93	5,144.38	536.41	50.77
Germany	87,816.90	1,105.60	6,824.36	1,214.99	51.62
Italy	57,005.15	662.66	2,017.34	531.80	24.32
Netherlands	26,667.63	277.92	1,135.47	322.55	15.26
Spain	36,390.90	413.79	995.34	611.12	17.16
Sweden	21,506.88	176.16	2,144.88	550.97	8.56
United Kingdom	97,515.85	1,056.94	3,595.13	751.21	35.27
Other old Member States	64,228.40	561.95	3,833.27	817.33	33.90
Newer Member States	39,998.44	1,063.17	974.15	280.61	26.67
European Union	**516,497.46**	**6,179.50**	**28,867.24**	**6,067.34**	**275.04**

Source: Eurostat, elaborated by Ivie and JRC-IPTS.

4. Comparison with other economies

This section places the EU in the international context by comparing its ICT R&D position with the most relevant players in the world economy: the United States, Canada, Australia, five Asian countries (Taiwan, Korea, Japan, China and India); three European countries not belonging to the EU (Russia, Norway and Switzerland); and one Latin American country (Brazil). The comparison is made for the two most recent years for which information is available, 2011 and 2012. It uses the *ICT sector Operational Definition*[30] in the JRC-IPTS database, following the same structure as previous chapters for comparability and consistency between the countries analysed.

4.1 ICT sector value added

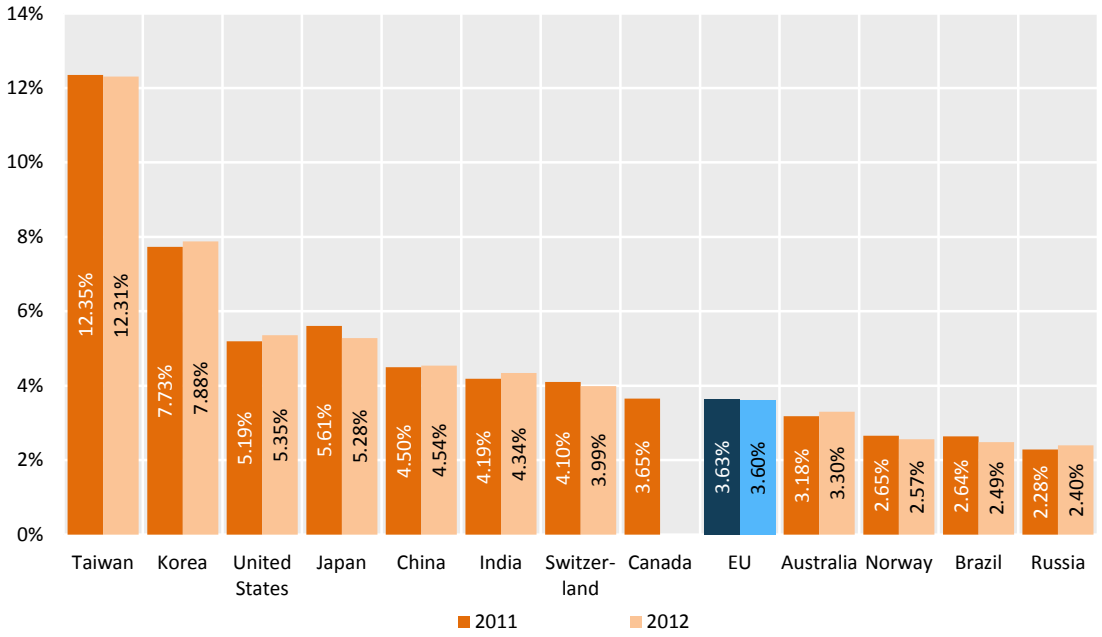
The importance of the ICT sector is very uneven among the countries considered. Figure 50 plots the weight of the value added (VA) generated by the ICT sector in total GDP. The message it gives is clear: the five Asian countries, together with the US, have the highest share of ICT sector in their VA. Of those, the high share of the ICT sector in Taiwan and Korea –especially the former– is outstanding. While ICT sector VA represented 3.60% of VA in the EU[31] in 2012, at 12.31% it was 3.4 times higher in Taiwan, and in Korea more than double (2.2 times higher) at 7.88%. These two countries are therefore the most ICT-oriented countries in the world economy. However, this share decreased in almost all countries between 2011 and 2012, except for the United States, India, Korea, Russia and Australia, all of which grew between 0.12 and 0.16 percentage points. On the other hand, China remained almost constant with a small growth of 0.04 percentage points.

A country's share in the total ICT sector VA depends on two conditions: 1. its ICT sector VA share of total VA; and 2. its economic size, as measured by total GDP or total employment. Figure 51 shows how total ICT sector VA is split among the different countries. As expected, due to their economic size, the US (32.16%) enjoys the highest share, followed by the EU countries (22.96%), China (14.31%) and Japan (12.04%). Thus, in 2012 these four players together represented 81.47% of total ICT sector VA produced by the thirteen economies selected for analysis.

[30] The *Comprehensive definition of ICT sector* is available mainly for EU Member States for the period 2008-2010. It corresponds to the definition given by the OECD in 2007. This definition includes ICT manufacturing industries, ICT trade industries and ICT services industries. Data in accordance with this classification are not available for some non-EU countries. See OECD definition: http://www.oecd.org/science/sci-tech/38217340.pdf. The *Operational definition of ICT sector* allows for an international comparison with non-EU countries over a longer period of time (2006-2012), as some of these countries do not have the necessary disaggregated information to estimate all the ICT sub-sectors included in the comprehensive definition. This definition takes into account the standard distinction between manufacturing and services, but does not include the following sectors: Manufacture of magnetic and optical media (268) and ICT trade industries (465). In addition, ICT services industries are only available for two sub-sectors: Telecommunication (61) and the aggregate Computer and related activities (5820, 62, 631, 951). See Technical report: http://ftp.jrc.es/EURdoc/JRC77364.pdf.

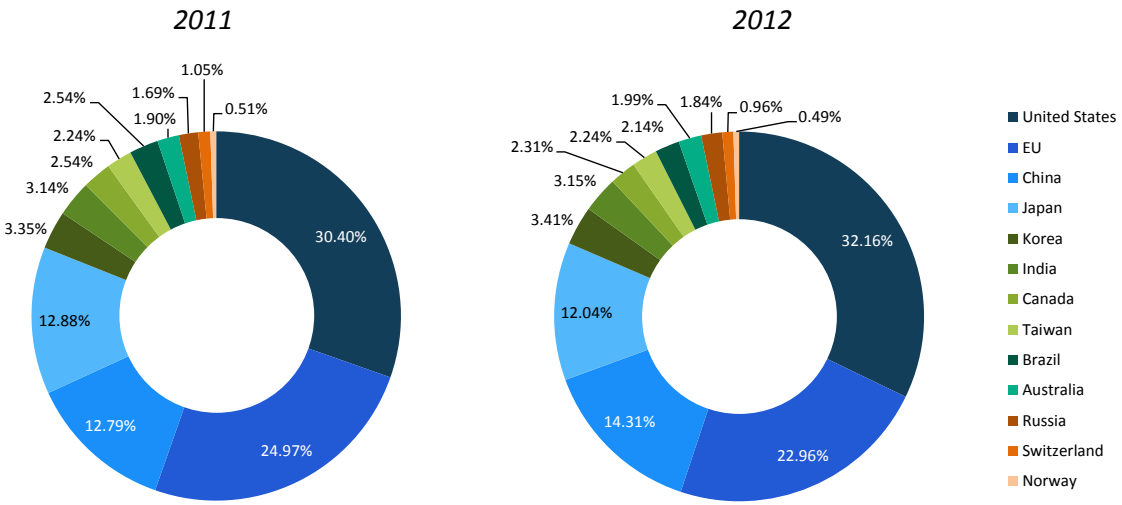
[31] Recall that in this chapter we are using the *Operational Definition*; some discrepancies may therefore arise between the figures provided in this chapter and in previous ones.

Figure 50: ICT sector VA share of GDP for the European Union and other economies (2011, 2012)



Note: ICT VA not available for Canada in 2012.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

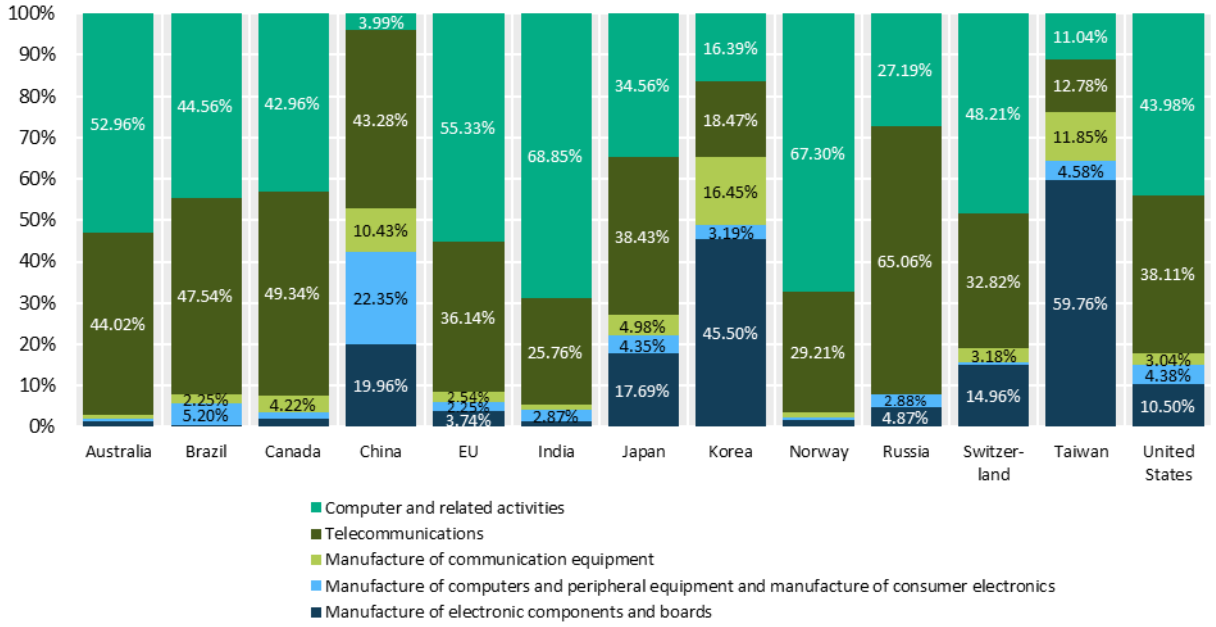
Figure 51: Distribution of ICT sector VA among the European Union and other economies (2011, 2012)



Note: 2011 for Canada for both years.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

Figure 52 reports the different ICT sub-sectors' shares of total ICT sector VA[32]. Of the five ICT sub-sectors represented in the figure, three stand out for their importance, especially in four Asian countries (China, Japan, Korea and Taiwan): *Manufacture of electronic components and boards; Computer and related activities;* and *Telecommunications.* Both Taiwan and Korea have a very high share of the first sector, *Manufacture of electronic components and boards*; China has a relatively high share of *Manufacture of computers and peripheral equipment and Manufacture of consumer electronics*; India and Norway have high shares of *Computer and related activities,* while Russia, Canada, Brazil and Australia[33] present the highest *Telecommunications* share of the thirteen economies considered. The most remarkable difference between the EU and the US is the former's relatively high share in *Computer and related activities,* together with its relative low share in *Manufacture of electronic components and boards* compared with the US.

Figure 52: Distribution of ICT sector value added by manufacturing and services sub-sectors for the European Union and other economies (2012)



Note: 2011 for Canada.

Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

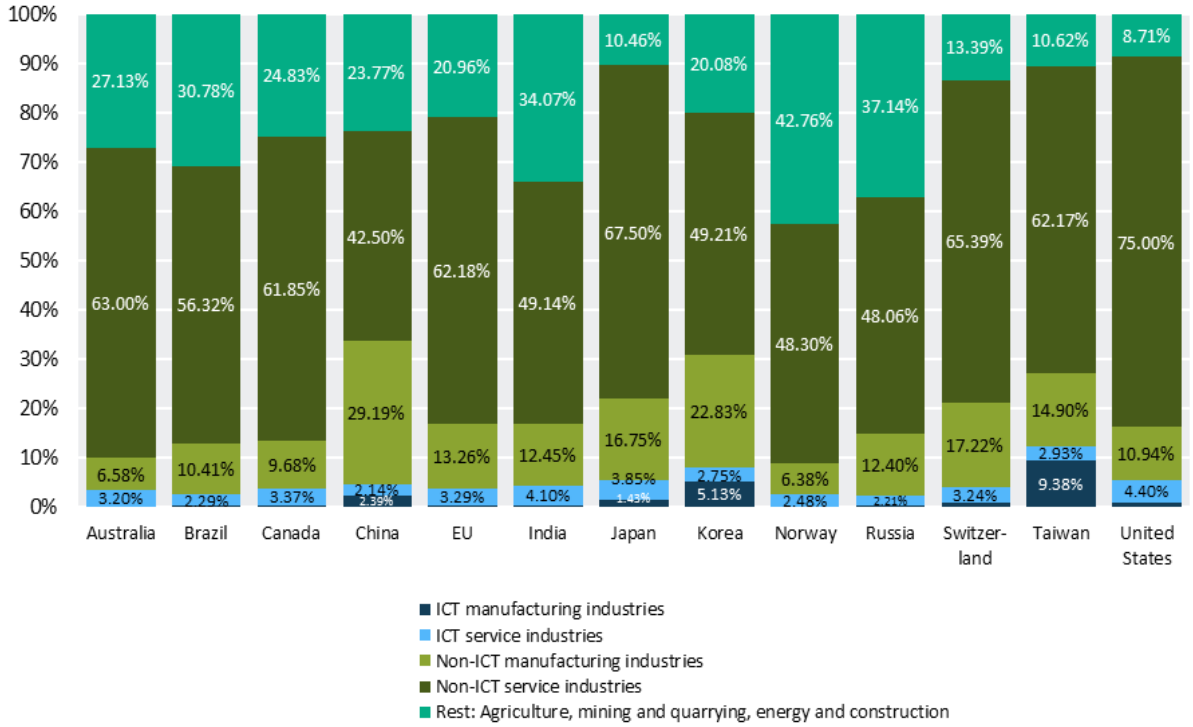
Figure 53 offers a complementary perspective by plotting the ICT and non-ICT activity shares of GDP, differentiating between manufacturing and services industries. As we have already seen (Figure 50) the ICT sector has a small share of GDP. ICT manufacturing sectors are relevant in terms of VA for only four Asian countries, Taiwan, Korea, China and Japan, while for the remaining countries its presence is almost nil, below 1% (0.96% in the US) of total GDP. For all the countries the highest share of GDP corresponds to non-ICT service industries. This is especially true for the US (75.00%), Japan (67.50%), Switzerland (65.39%) and Australia (63.00%). Non-ICT manufacturing sectors are very relevant in China (29.19%) and also Korea (22.83%), while the sectors that fall under the "Rest" heading (agriculture, mining and quarrying, energy and construction) are relatively more significant in Norway (42.76%), Russia (37.14%) and India (34.07%). A comparison of the EU and the US reveals the main difference as the relatively higher share in the US of non-ICT services

[32] The figure represents five ICT sub-sectors instead of the six for which the database offers information. It combines *Manufacture of computers and peripheral equipment* with *Manufacture of consumer electronics* in order to make the information more easily readable.

[33] Data for Canada refers to 2011.

and the lower share of the "Rest" component, together with the higher share of the ICT sector already highlighted.

Figure 53: ICT sector value added share of GDP and comparison with non-ICT economic activities. European Union and other economies (2012)



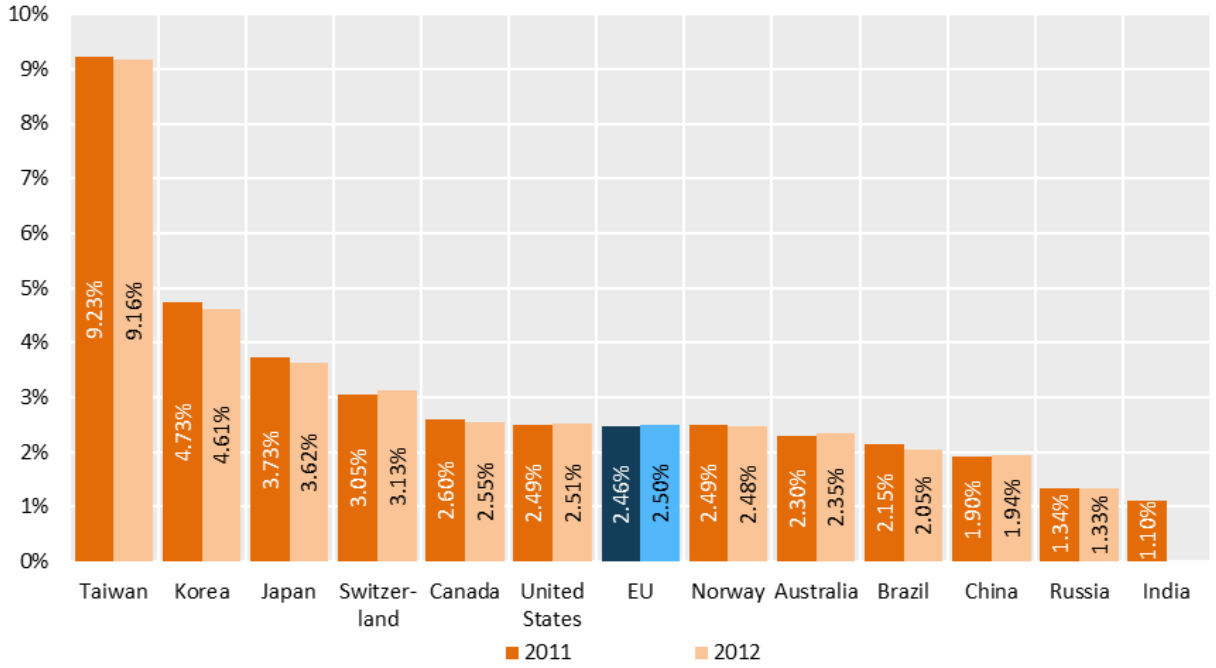
Note: 2011 for Canada. Non-ICT service industries include total Trade.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

4.2 ICT sector employment and ICT sector labour productivity

4.2.1 ICT sector employment

Figure 54 plots the ICT sector employment share of total employment. The findings it reveals are not so different from those for value added. Taiwan, Korea, and Japan are, again, the countries with the highest shares of ICT sector, although their share fell between 2011 and 2012. The only economies that experienced an increase in the ICT sector employment share were Switzerland, Australia, China, the EU and the US, with growth between 0.02 and 0.07 percentage points. The EU had a similar share (2.50%) to the United States and Norway (2.51% and 2.48% respectively)

Figure 54: ICT sector employment share of total employment for the European Union and other economies (2011, 2012)



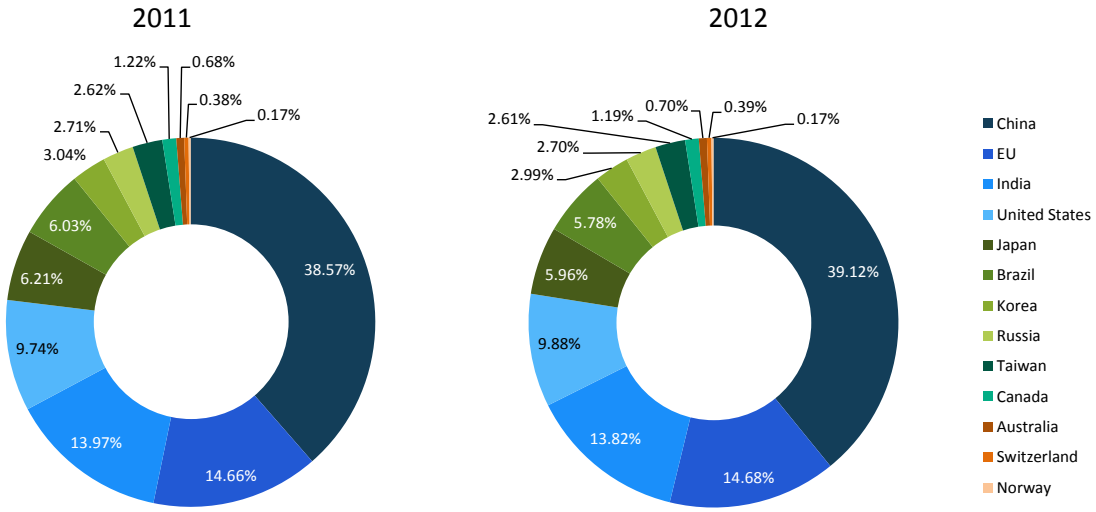
Note: 2012 ICT data were not available for India.

Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

Figure 55 shows each country's contribution to the aggregated employment of the thirteen selected economies.[34] Now the picture is rather different from that obtained for VA (Figure 51). The highest contribution to total ICT sector employment in 2012 corresponded to China (39.12%), followed at a large distance by the EU (14.68%, less than half of China's contribution), India (13.82%), the US (9.88%) and Japan (5.96%). The sum of these five shares amounts to 83.46% of ICT sector employment. It is interesting to recall that the share of the ICT sector in the EU represented 22.96% in terms of ICT sector aggregated VA, but only 14.68% in terms of ICT sector aggregated employment. For the US the gap is even more striking: 32.16% for VA and 9.88% for employment. On the other hand, the contribution of the various economies to aggregated ICT sector employment remained practically constant between 2011 and 2012, which was not the case for VA (see Figure 51), except for China and the US with 0.55 and 0.15 percentage points share increments, respectively.

[34] Recall that the information for India refers to 2011 instead of 2012.

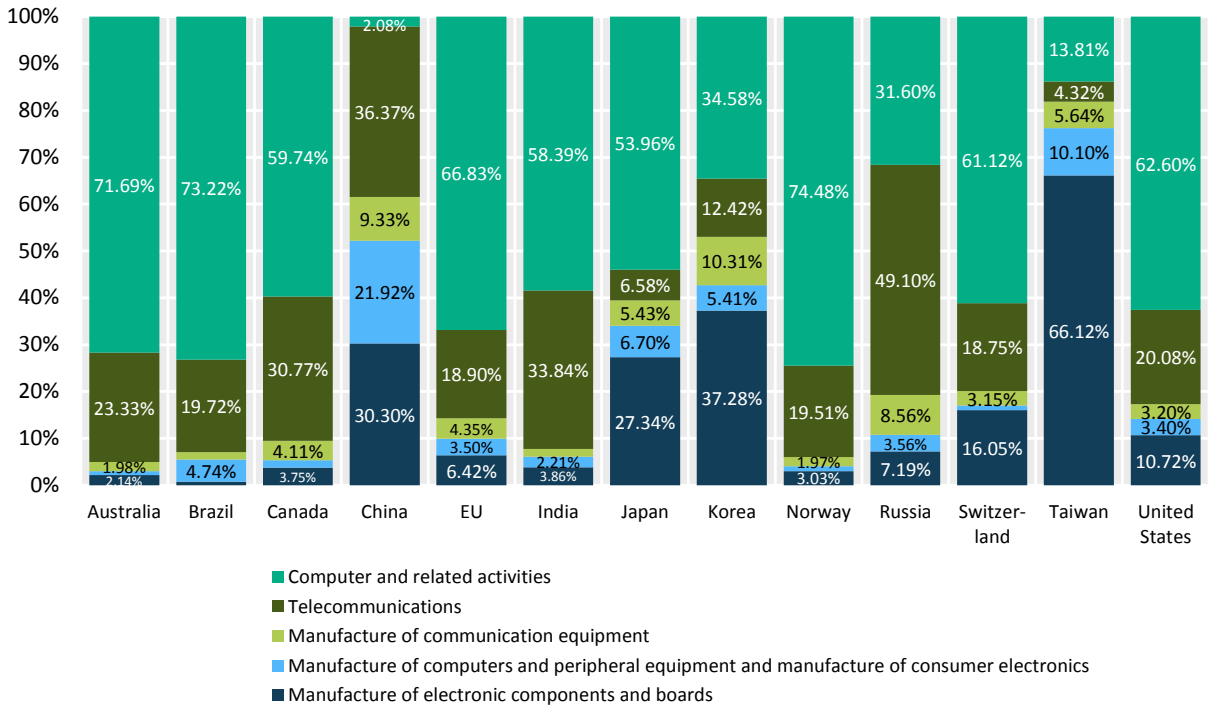
Figure 55: Distribution of ICT sector employment among the European Union and other economies (2011, 2012)



Note: 2011 for India for both years.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

Figure 56 plots the shares of the employment in five ICT sub-sectors on total ICT sector employment. The picture it reveals is similar to that provided by Figure 52, which gave the same information but in reference to VA rather than employment. As before, three ICT sub-sectors show the highest share: *Manufacture of electronic components and boards*, which is especially relevant for four Asian countries –Taiwan, Korea, China and Japan– and also for Switzerland. *Telecommunications* has a high share in total ICT sector employment in almost all countries, but it is especially high in Russia, China, India and Canada. The *Computer and related activities* sub-sector is very relevant for Norway, Brazil and Australia, while for China and Taiwan the contribution of *Manufacture of computers and peripheral equipment and manufacture of consumer electronics* is also relevant. The main difference to emerge in a comparison of the EU and the US is the relatively high US share of the *Manufacture of electronic components and boards and Telecommunications* sub-sectors and the low share of *Computer and related activities*.

Figure 56: Distribution of ICT sector employment by manufacturing and services sub-sectors for the European Union and other economies (2012)

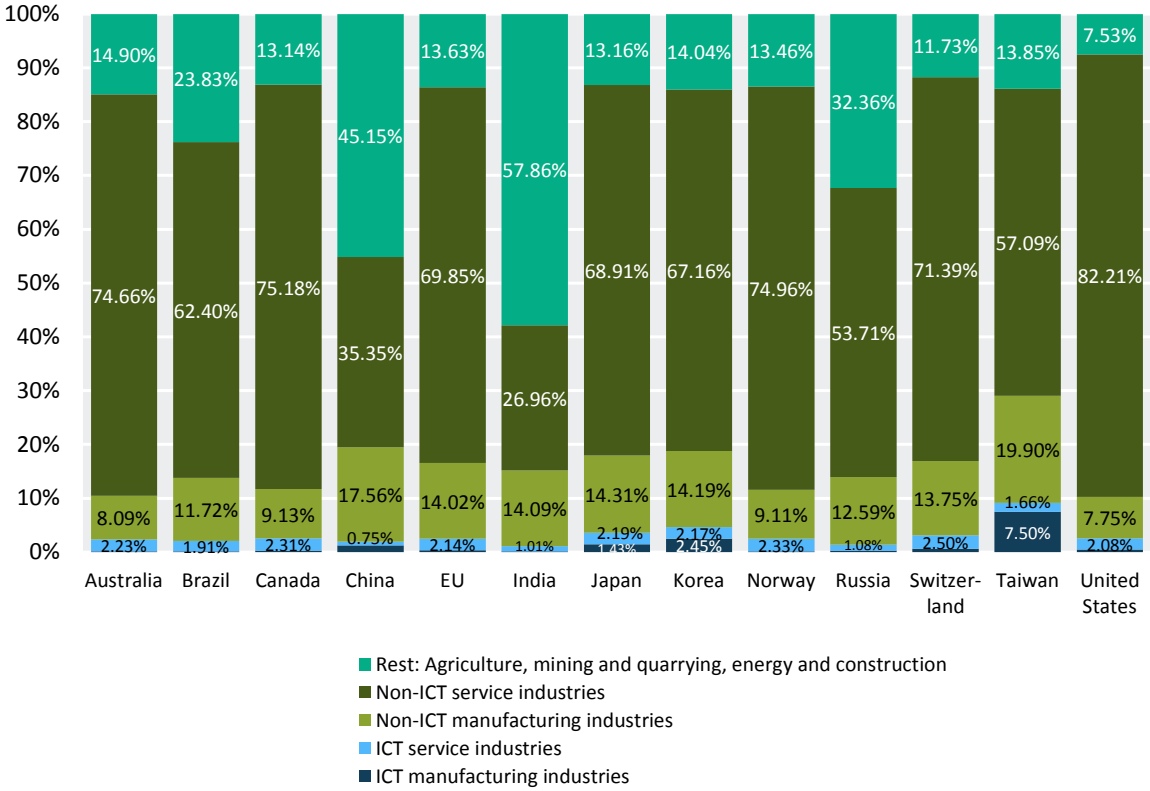


Note: 2011 for India.

Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

Figure 57 shows the distribution of total employment between ICT and non-ICT activities, as well as between manufacturing and services. The image this figure provides is very different from Figure 53, which contained similar information but for VA rather than employment. Generally speaking, in developed countries the contribution of non-ICT service industries VA to total GDP is lower than the contribution to total employment. For instance, in the EU the contribution of non-ICT service industries VA to GDP amounted to 62.18%, while for employment the percentage was 69.85%. A similar difference can be observed in the US with a 75.00% share in GDP, as compared with an 82.21% share in total employment. For less developed countries, and as expected, the contribution of the "Rest" industries (agriculture, mining and quarrying, energy and construction) is higher in terms of employment than in terms of GDP. This is especially true –also as expected– for India and China. The most notable fact when comparing the EU with the US is the higher share of non-ICT services industries and the lower share of non-ICT manufacturing industries in the US, together with the "Rest" industries.

Figure 57: Share of ICT sector employment in total employment and comparison with non-ICT economic activities. European Union and other economies (2012)



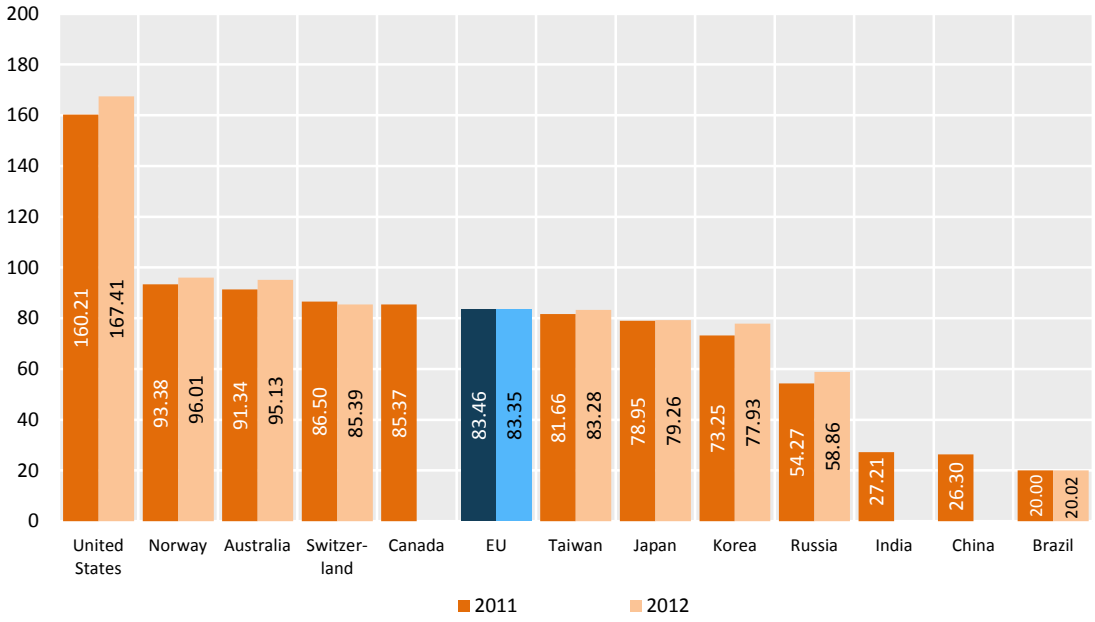
Note: 2011 for India. Non-ICT service industries include total Trade.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

4.2.2 ICT sector labour productivity

The profiles followed by GDP and employment in the different countries and sectors have their counterpart in the levels of labour productivity achieved, since this variable is the ratio between the two. Figure 58 shows the levels of labour productivity in the ICT sector (panel a), ICT manufacturing (panel b) and ICT services (panel c), expressed in thousands of euros PPS per worker. Now the picture is rather different from what we have reported in the previous sections. The United States leads in total ICT sector labour productivity, ICT manufacturing and ICT services. Norway lies in second position –due to its more productive ICT service sector– followed by Australia. Brazil, China, India and Russia are found at the opposite end of the spectrum; while the three large ICT countries –Taiwan, Korea and Japan– have lower ICT sector labour productivity levels than the EU average.

Figure 58: ICT sector labour productivity for the European Union and other economies (thousand EUR PPS per person; 2011, 2012)

a) ICT total



b) ICT manufacturing

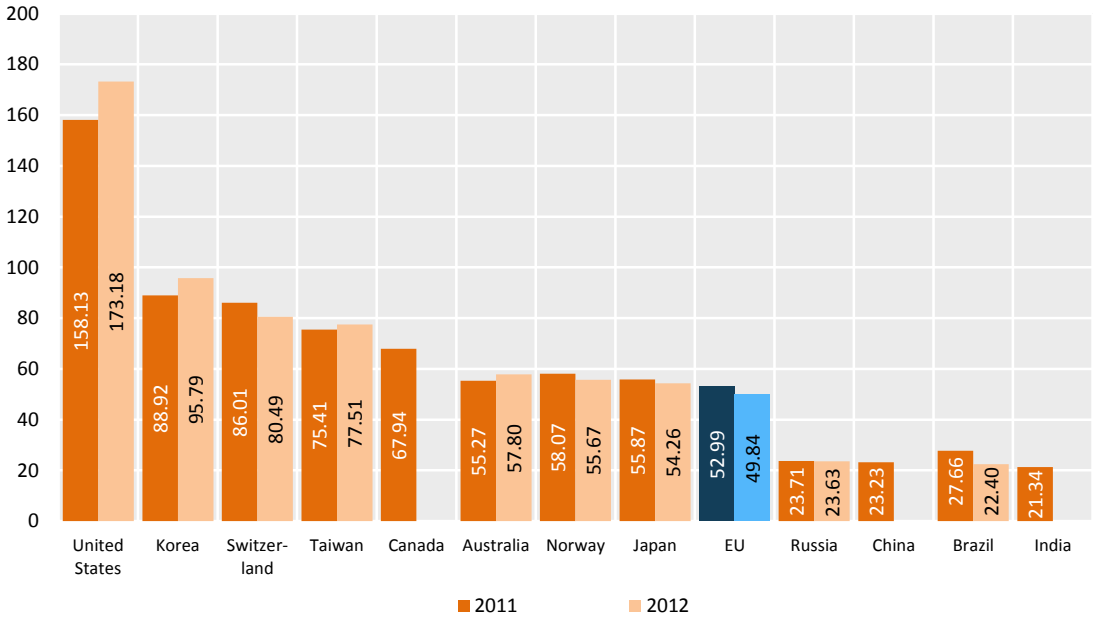
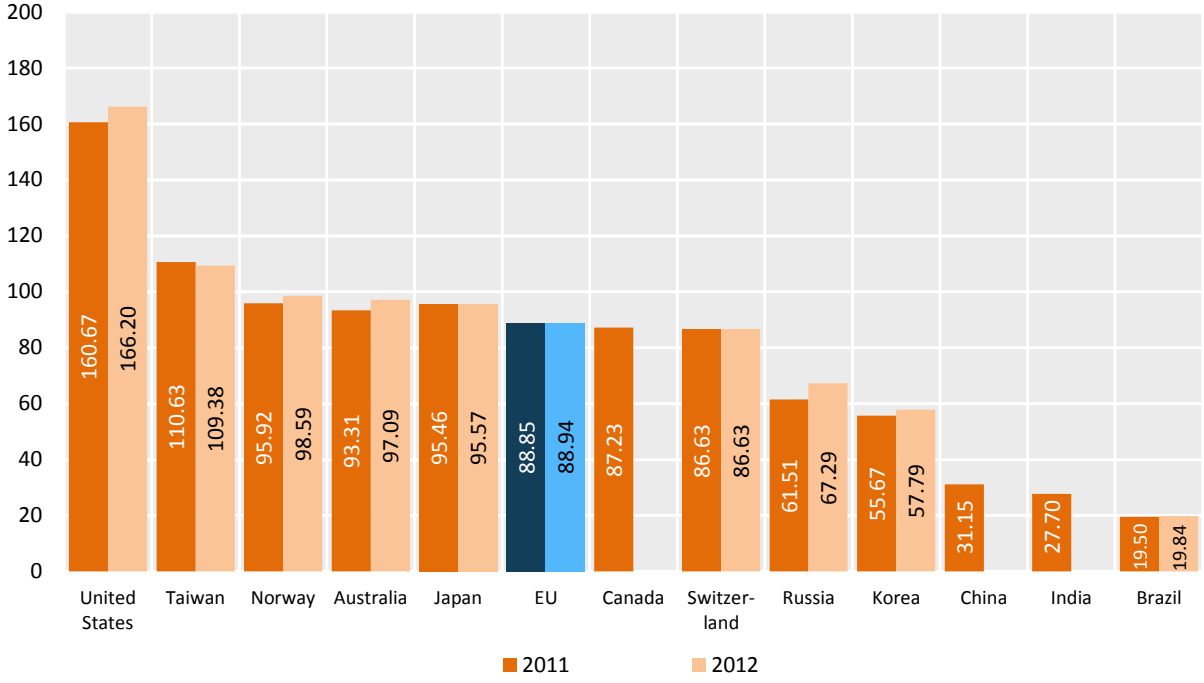


Figure 58 (cont.): ICT sector labour productivity for the European Union and other economies (thousand EUR PPS per person; 2011, 2012)

c) ICT services



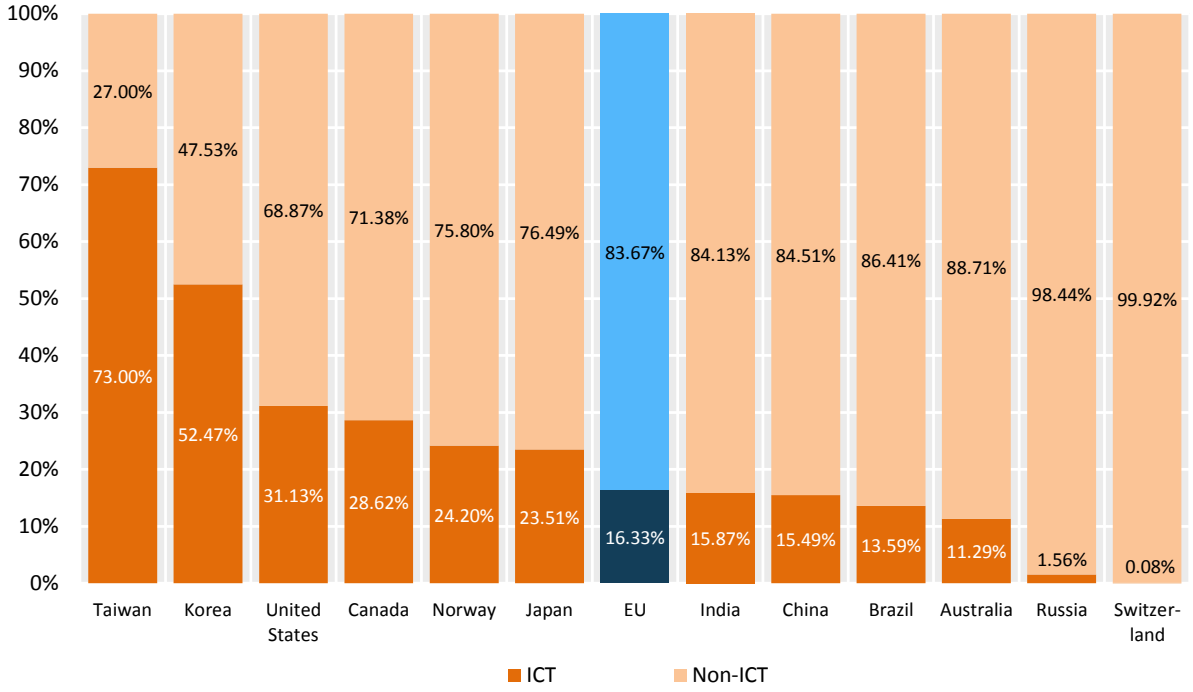
Note: 2012 data were not available for Canada, China and India.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

4.3 ICT sector business enterprise R&D (BERD) expenditure

Business enterprise expenditure on R&D (BERD) is very unevenly distributed among ICT and non-ICT sectors in the countries investigated. As Figure 59 shows, in 2012 more than 70% of total BERD (73.00%) in Taiwan was devoted to the ICT sector, 52.47% in Korea and 31.13% in the US. In the EU the share was around half that of the US (16.33%), and it was even lower in India (15.87%)[35]. The other countries recorded different ratios: China (15.49%), Brazil (13.59%), Australia (11.29%), Russia (1.56%) and Switzerland (0.08%).

[35] The figures for China, India and Russia should be interpreted with caution since the available information is scarce and not fully comparable. In the three countries the correspondence between the sector classification and the one followed in the PREDICT methodology is an approximation. Many sectors are estimated as there is not enough available official disaggregation. In China, Korean weights are used for sectors 63 and 58. In India, United Kingdom's weights are used for sectors 63 and 58. In Russia, only GERD (Gross Domestic Expenditure on Research and Development) data are available, so this structure is applied to total BERD in order to estimate the sub-sectors. In addition, the Russian sector classification uses NACE Rev 1.1 and not NACE 2, so the sectoral correspondence is not exact.

Figure 59: Share of ICT and non-ICT sector BERD for the European Union and other economies (2012)



Note: 2011 for Brazil. ICT sector BERD for Switzerland includes only ICT manufacturing for the operational sector definition.

Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

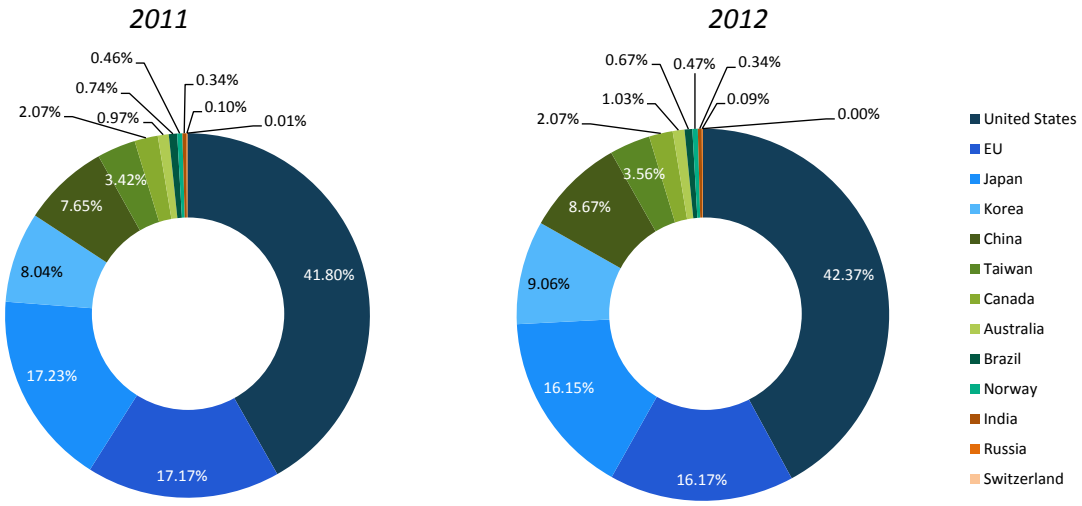
ICT sector BERD is much more concentrated in a small number of countries than VA or employment. According to the information provided in Figure 60, 42.37% of total ICT sector BERD of the thirteen economies considered was made in the United States in 2012. The EU follows –but at a large distance– representing 16.17% of the total, close to the 16.15% contribution of Japan, and the even smaller Korean and Chinese contributions (9.06% and 8.67%, respectively). When Taiwan (3.56%) is also considered, these six countries represent 95.98% of total ICT sector BERD undertaken by the thirteen countries under consideration. Note also that while the contributions of the EU and Japan decreased between 2011 and 2012, those of Korea, China and the US increased.

Figure 61 plots the distribution of ICT sector BERD between ICT manufacturing and services sub-sectors in 2012. Now all the sub-sectors appear almost equally relevant in one way or another. *Manufacture of electronic components and boards* is very relevant for Korea, Taiwan, Switzerland[36], Russia, and to a lesser extent for the US, China and Japan. *Manufacture of computers and peripheral equipment*, together with *Manufacture of consumer electronics*, is relevant for Japan, China, Taiwan and Brazil, and to a lesser extent for the United States and Russia. *Manufacturing of communication equipment* has a high share in ICT sector BERD in Canada, China, Japan, Russia and the EU. For *Telecommunications* the highest shares are reflected for Brazil and Australia. Finally, *Computer and related activities* have a very high presence in India, Norway and Australia (this sector accounts for more than half of its ICT sector BERD). Overall, ICT sector BERD is more evenly distributed than ICT sector VA or ICT sector employment among the ICT sub-sectors. The main

[36] The comparison of Switzerland with other economies in terms of ICT sector BERD should be made with caution given that ICT sector BERD in this country does not include the ICT services sub-sector due to lack of information.

differences between the EU and the US is the much higher US share of *Manufacture of electronic components and boards* and *Manufacture of computers and peripheral* equipment, and its lower share in *Manufacture of communication equipment* and *Telecommunications.*

Figure 60: Distribution of ICT sector BERD among the European Union and other economies (2011, 2012)

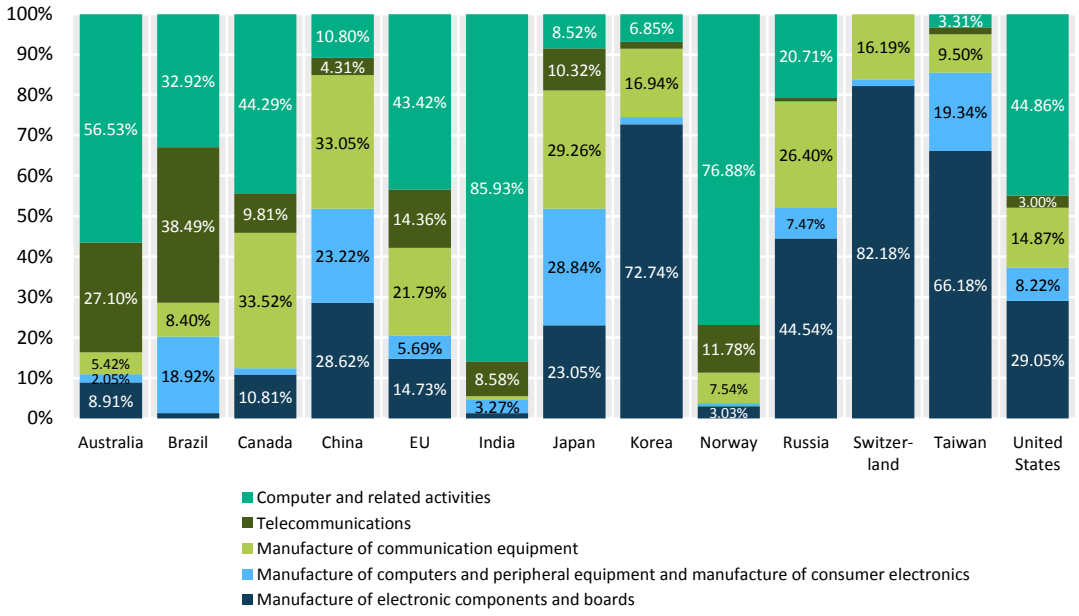


Note: 2012 for Switzerland for both years. ICT sector BERD for Switzerland includes only ICT manufacturing for the operational sector definition.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

The distribution of BERD by ICT and non-ICT sub-sectors, and between manufacturing and service industries, is shown in Figure 62.[37] As already highlighted, BERD in ICT manufacturing industries is very high in Taiwan and Korea and it is relatively higher in Japan, the US, China and Canada than in the other countries. BERD in non-ICT manufacturing industries is very important in all countries, except for Russia, but it is especially high in China, India, Japan and Switzerland. When the EU and the US are compared the most notable fact is the lower US share of non-ICT industries –both manufacturing and services– and thus, the higher share of ICT industries.

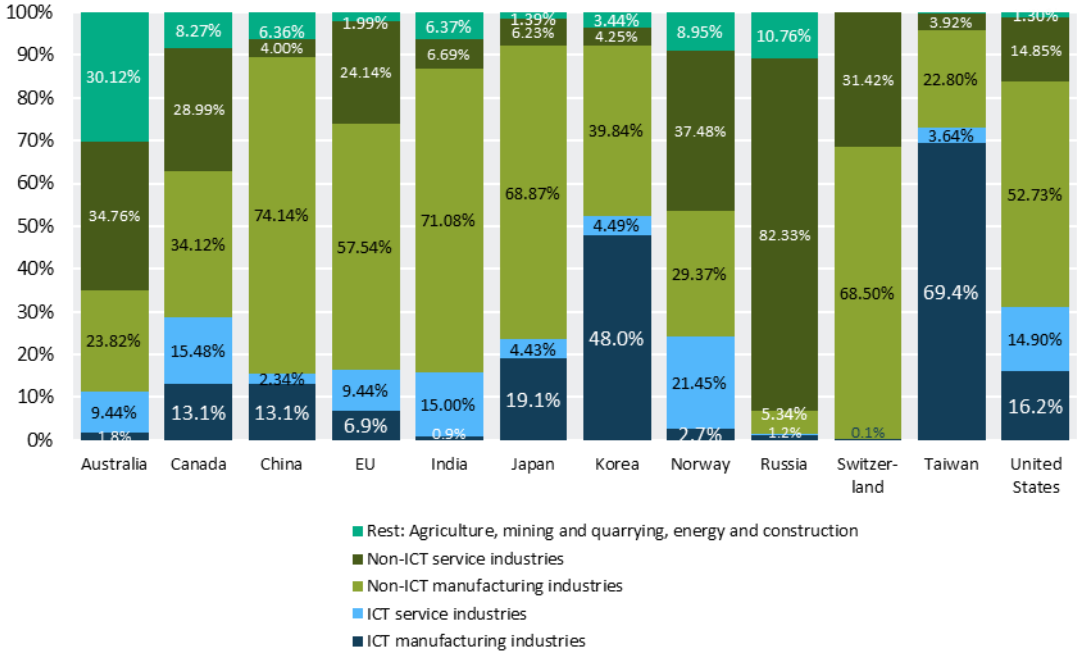
[37] Information for Brazil is not available due to lack of data for BERD in the service sector.

Figure 61: Distribution of ICT sector BERD by manufacturing and services sub-sectors for the European Union and other economies (2012)



Note: 2011 for Brazil. Switzerland: data available only for ICT-manufacturing sub-sectors, as ICT sector BERD for Switzerland includes only ICT manufacturing for the operational sector definition.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

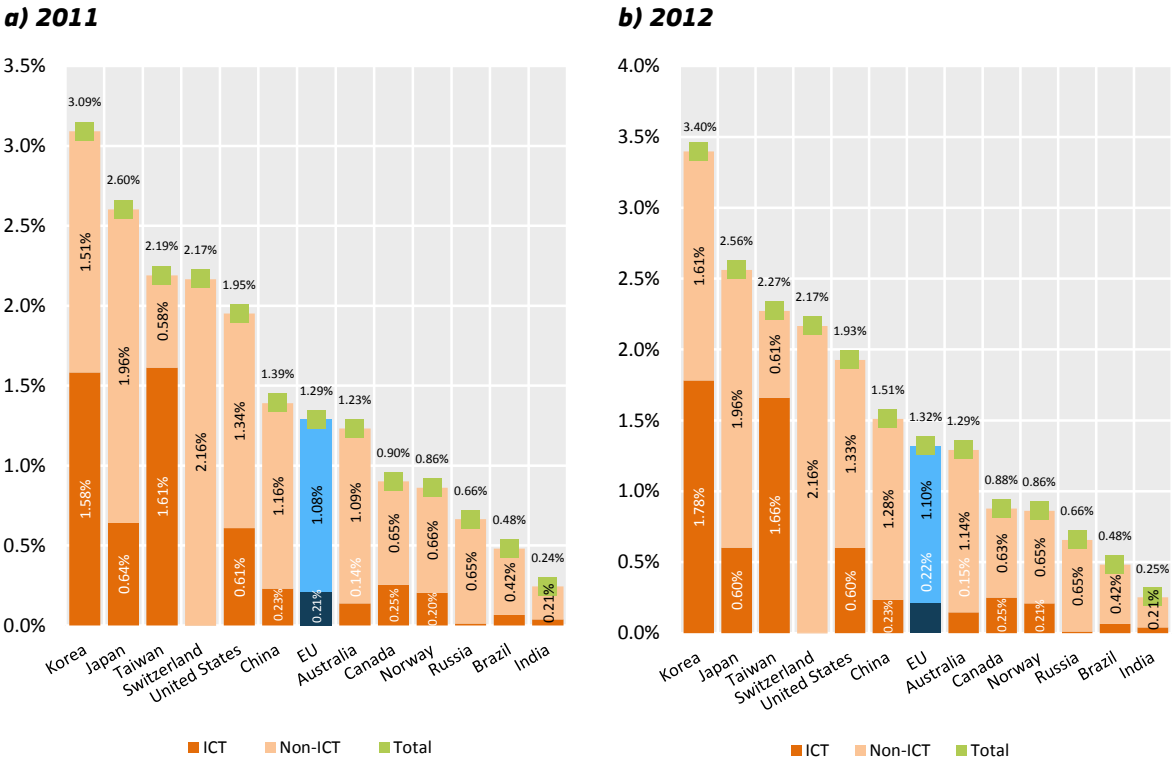
Figure 62: ICT sector BERD share of total BERD and comparison with non-ICT economic activities. European Union and other economies (2012)



Note: Data were not available for Brazil. Non-ICT service industries include total Trade.
ICT sector BERD for Switzerland includes only ICT manufacturing for the operational sector definition.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

BERD intensity measures the weight of BERD in GDP. Figure 63 plots the BERD/GDP ratio for the years 2011 and 2012, distinguishing between ICT and non-ICT sector. The order of the countries remained almost constant in both years. The highest BERD intensity corresponded to Korea (3.40%) in 2012, and three other countries had BERD/GDP ratios above 2%: Japan (2.56%), Taiwan (2.27%) and Switzerland (2.17%). For the EU the corresponding figure was 1.32%, and in the US 1.93%. As expected, ICT sector BERD intensity was relatively very high in Korea and Taiwan, followed, at a significant distance, by Japan and the US. ICT sector BERD intensity accounted for 0.22% in the EU, compared with 1.78% in Korea and 1.66% in Taiwan, or 0.60% in Japan and the US.

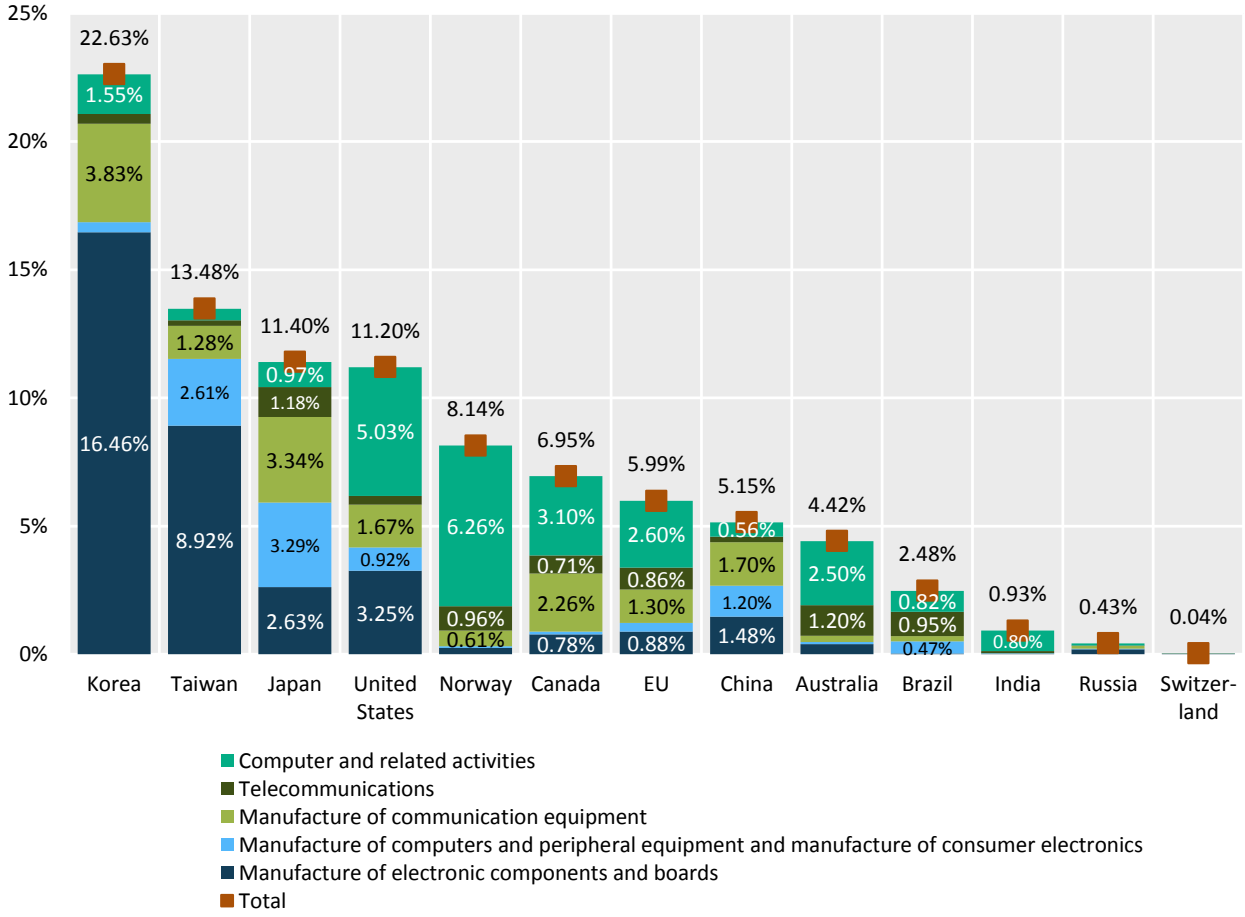
Figure 63: Contribution of ICT and non-ICT sector BERD to total BERD intensity (BERD/GDP). European Union and other economies (2011, 2012)



Note: 2012 for Switzerland for both years and 2011 for Brazil for both years.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

Figure 64 plots ICT sector BERD intensity (ICT sector BERD/ICT sector VA) for the total ICT sector as well as for each of the five sub-sectors considered. As in the previous cases, Korea and Taiwan also stand out for this variable. ICT sector BERD intensity in Korea reached 22.63% in 2012, followed by Taiwan (13.48%) and Japan (11.40%). The US (11.20%) came next while the figure for the EU was 5.99%. Again, in Korea and Taiwan the ICT sector with the highest BERD intensity is *Manufacture of electronic components and boards*. This sub-sector is also important for the US, China and Japan. *Computer and related activities* is the most prominent sub-sector in Norway, the US, Canada and Australia; it also has the highest BERD intensity in the EU, followed by *Manufacture of communication equipment*.

Figure 64: Contribution of ICT sub-sectors to ICT sector BERD intensity (ICT sector BERD/ICT sector VA). European Union and other economies (2012)



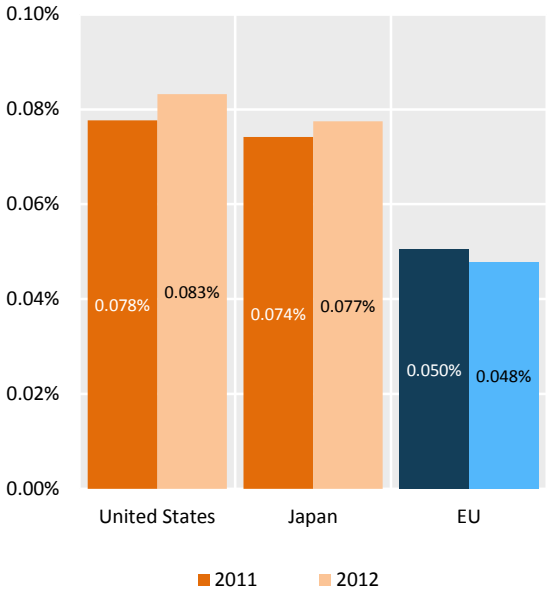
Note: 2011 for Canada and Brazil. Switzerland includes only ICT manufacturing sub-sectors.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

4.4 Public funding of ICT R&D

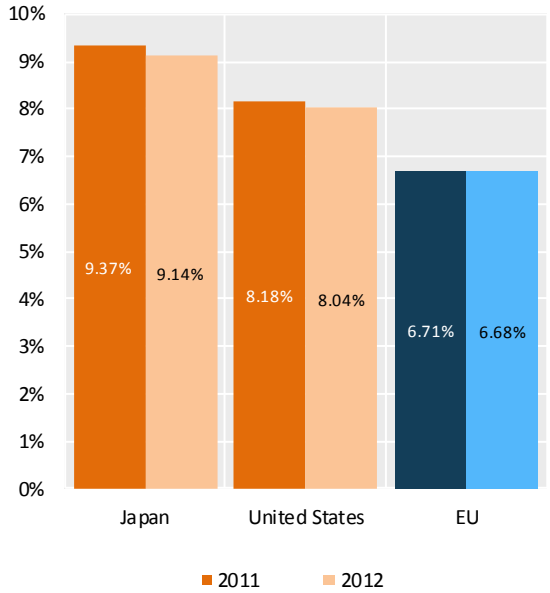
Figure 65 shows ICT GBAORD as the share in GDP and in total GBAORD for the EU, Japan[38] and the United States in 2011 and 2012. In both years, the US and Japan led, with shares in total GDP of 0.083% and 0.077% in 2012, followed by the EU at a certain distance (0.048%). Regarding the share of ICT GBAORD with respect to total GBAORD in 2012, both Japan (9.14%) and the US (8.04%) were above the EU (6.68%), although in this case the difference is not as big as with the share in total GDP.

Figure 65: Share of ICT GBAORD in GDP and total GBAORD for the European Union, the United States and Japan (2011, 2012)

a) Share in GDP



b) Share in total GBOARD



Note: Figures for Japan are not fully homogeneous with the EU and the United States (see methodology).
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

4.5 ICT sector R&D personnel[39]

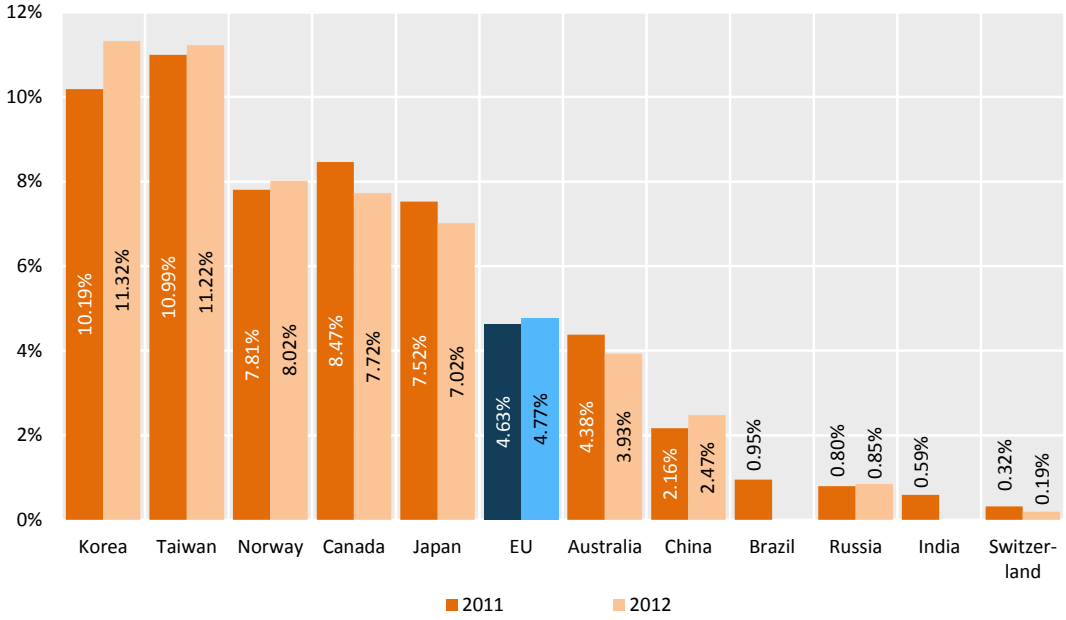
Figure 66 plots the share of ICT sector R&D personnel (expressed in full-time equivalent terms) in total ICT sector employment (expressed in terms of headcounts). As in many other variables already reviewed, Korea and Taiwan take the lead. In Korea the share of ICT sector R&D personnel amounted to 11.32% in 2012, and in Taiwan it was 11.22%. It is interesting to note the high share for Norway (8.02%), and also for Canada (7.72%). By contrast, in the EU the equivalent percentage

[38] Methodology for Japan is not fully homogeneous with the EU and the US due to lack of equivalent high level data disaggregation.

[39] Data limitations impede inclusion of information for the ICT personnel variable for the US. Although the *Survey of Industrial Research and Development* (SIRD) and *Business R&D and Innovation Survey* (BRDIS) offer domestic R&D employment figures, these are not comparable with the definition of FTE R&D personnel used by OECD and Eurostat (following the Frascati Manual), since they only include R&D scientists and engineers.

was less than half at 4.77%. Note that Korea[40], China, Taiwan, Norway, Russia, but also the EU, showed increases in the ICT sector personnel ratio between 2011 and 2012.

Figure 66: ICT sector R&D personnel (FTE) share of total ICT sector employment for the European Union and other economies (2011, 2012)



Note: ICT employment data are not available for India for 2012. Switzerland: 2008 for 2011. Brazil: ICT personnel data are not available for 2012. United States is not included due to a lack of homogeneous ICT R&D personnel data.

Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

The absence of reliable data for the US limits the interest of the information in Figure 67, which shows the contribution of the twelve remaining economies to total ICT sector R&D personnel (excluding the US). For these twelve, the EU presents the second highest share in 2012, only behind China, followed by Japan, Korea, Taiwan and Canada. The shares of Japan, the EU, Canada and Taiwan fell between 2011 and 2012, whereas the other two leading countries, China and Korea, gained weight.

The ICT and non-ICT sector share of total R&D personnel is shown in Figure 68. Taiwan (67.49% of R&D personnel assigned to the ICT sector) and Korea (45.79%) are the leading countries. Norway (28.70%), Japan (27.42%), Canada (26.61%) and Brazil (21.01%) have higher shares than the EU (18.78%).

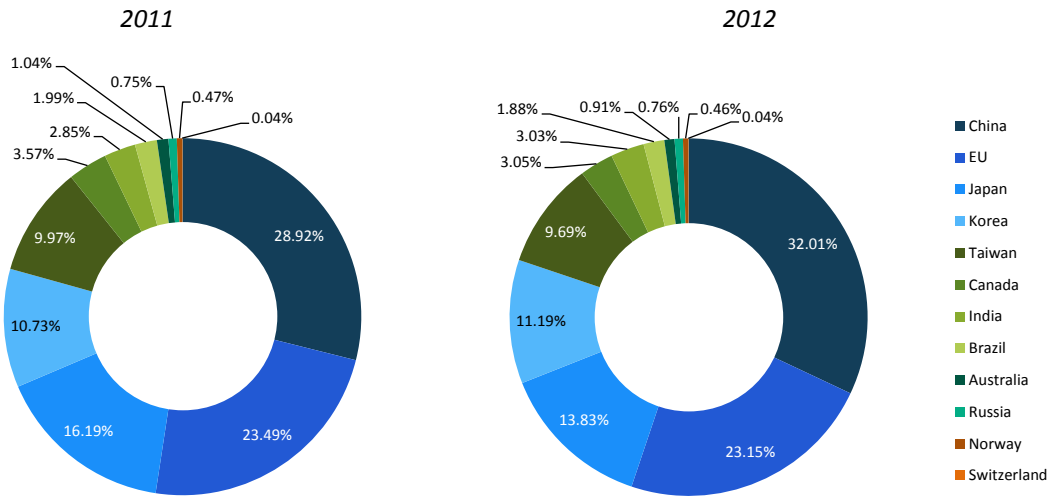
Finally, Figure 69 shows the distribution of ICT sector R&D personnel in manufacturing and services sectors. The overwhelming superiority of manufacturing in the Asian countries is striking, but the position of Russia (87.20%) is also noteworthy[41]. 92.18% of Taiwan's ICT sector R&D personnel worked in manufacturing; the share was also high in Russia (87.20%), China (85.19%), Japan (84.83%) and Korea (79.72%). Compared with these percentages the share of ICT sector R&D personnel in the EU ICT manufacturing sector is very modest (30.85%). These figures again

[40] As for the BERD variable, the figures for China, India, Russia, and also Korea should be interpreted with caution since the available information is scarce and not fully comparable. Chinese, Korean and Russian data are estimated (see methodological notes).

[41] Information on Switzerland's ICT services R&D personnel is not available, yielding an abnormal 100% of share of manufacturing.

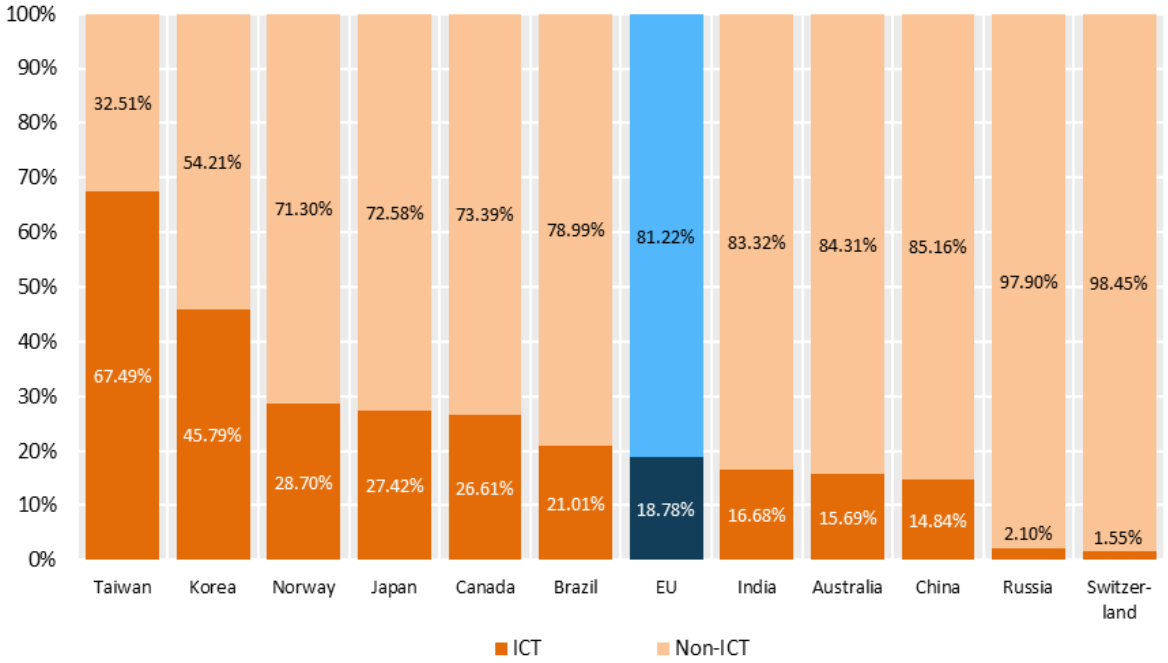
highlight the prominence of the ICT sector in the Asian countries –especially in their manufacturing sub-sectors– and the opposite situation of the EU, with a lower presence of the ICT sector, and its higher specialisation in ICT service sub-sectors.

Figure 67: Distribution of ICT sector R&D personnel (FTE) among the European Union and other economies (2011, 2012)



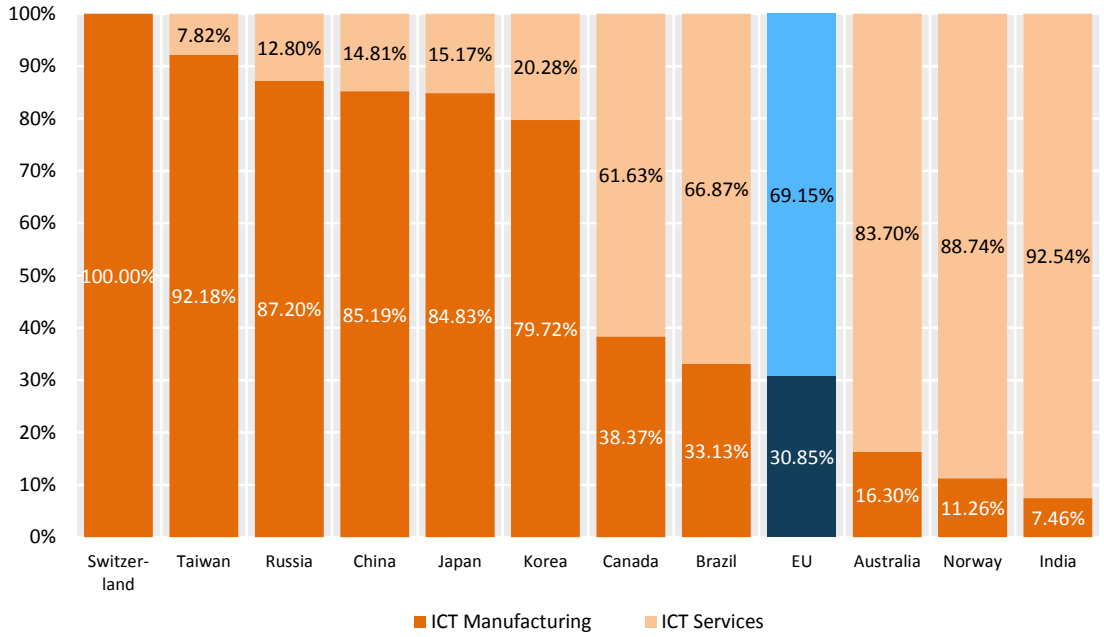
Note: 2012 for Brazil for both periods. 2008 for Switzerland for 2011. United States is not included due to a lack of homogeneous ICT R&D personnel data.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

Figure 68: Share of ICT and non-ICT sector R&D personnel (FTE) for the European Union and other economies (2012)



Note: 2011 for Brazil. United States is not included due to a lack of homogeneous ICT R&D personnel data.
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

Figure 69: Distribution of ICT sector R&D personnel (FTE) by manufacturing and services for the European Union and other economies (2012)



Note: 2011 for Brazil. United States is not included due to a lack of homogeneous ICT R&D personnel data. Data for Switzerland are available only for ICT manufacturing sectors.

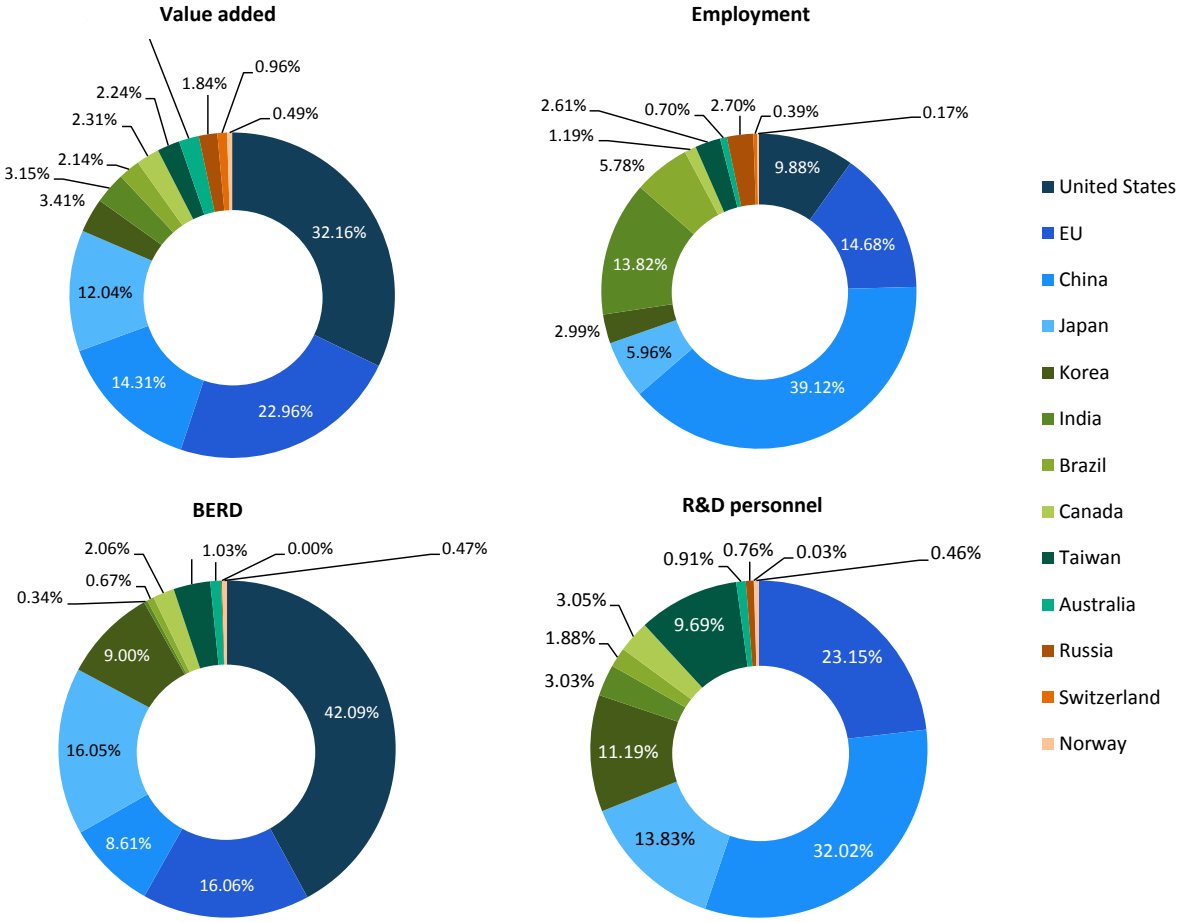
Source: See methodological notes, elaborated by Ivie and JRC-IPTS.

4.6 Comparison of indicators and data summary

Figure 70 summarises ICT sector value added, employment, BERD and R&D personnel in terms of the countries' contributions in 2011.

- The US enjoyed the highest share in ICT sector VA (32.16%) in 2012, followed by the EU (22.96%), China (14.31%), Japan (12.04%) and Korea (3.41%). These five players together represent 84.87% of the total ICT sector VA produced by the thirteen countries analysed. These shares were 30.40% for the US in 2011, followed by the EU (24.97%), China (12.79%, Japan (12.88%) and Korea (3.35%), representing together 84.39%.
- In terms of ICT sector employment, the picture is rather different from that obtained for ICT sector VA. The highest contribution to total ICT sector employment in 2012 corresponded to China (39.12%; 38.57% in 2011), followed by the EU (14.68%, less than half of China's contribution; and 14.66% in 2011), India (13.82%; 13.97% in 2011), the United States (9.88%; 9.74% in 2011) and Japan (5.96%; 6.21 in 2011). The sum of these five shares amounts to 83.46% of ICT sector employment in the thirteen countries analysed (83.14% in 2011).

Figure 70: Comparison of ICT sector value added, employment, R&D personnel and BERD for other economies and the EU (2012)



Note: ICT totals correspond to the operational definition of ICT sector.

Value added: 2011 for Canada. Employment: 2011 for India. R&D personnel and BERD: 2011 for Brazil. Data are not available for R&D personnel for the United States (data are not homogeneous).

Source: Eurostat, elaborated by Ivie and JRC-IPTS.

- The share of the ICT sector in the EU represents 22.96% in terms of ICT aggregate VA, but only 14.68% in terms of ICT sector employment. For the US the gap is even more striking: 32.16% for VA and 9.88% for employment. This gap was lower for the US and higher for the EU in 2011.
- ICT sector BERD is much more concentrated in a small number of countries than value added or employment: 42.09% of total ICT sector BERD is made in the United States (41.81% in 2011). The EU follows representing 16.06% of the total, close to Japan with 16.05%, and followed by the even smaller contributions of Korea (9.00%) and China (8.61%). In 2011, Japan represented a slightly higher percentage than the EU (17.23% and 17.17%, respectively). These five countries represent 91.81% of total ICT sector BERD undertaken by the thirteen economies considered (91.90% in 2011).
- The absence of reliable data for the US limits the interest of the information about the contribution of the twelve remaining economies to total ICT sector R&D personnel (excluding the US). For these twelve, the EU presents the second highest share in 2012, only behind China, followed by Japan, Korea, Taiwan and Canada. This order is the same as in 2011.

Finally, Table 5 presents the main variables analysed in this chapter.

Table 5: Summary table of ICT indicators for the European Union and other economies (2012)

ICT total:	ICT sector Value added	ICT sector Employment	ICT sector BERD	ICT GBAORD	ICT sector R&D personnel
	(Millions of current EUR)	(thousand persons employed)	(Millions of current EUR)	(Millions of current EUR)	(thousand full-time equivalent)
European Union	466,598.78	5,597.75	27,936.97	6,067.34	266.77
United States	653,610.45	3,766.82	73,226.1	9,008.55	-
Japan	244,804.94	2,270.66	27,915.39	3,291.42	159.31
Norway	9,987.42	66.63	812.96	-	5.35
Switzerland	19,605.68	149.33	8.48	-	0.29
Australia	40,442.39	267.43	1,786.25	-	10.50
Brazil	43,574.89	2,203.11	1,165.99	-	21.71
Canada	46,958.3	455.29	3,579.59	-	35.17
China	290,826.33	14,912.12	14,987.15	-	368.86
India	63,964.423	5,269.48	592.09	-	34.89
Korea	69,229.82	1,138.97	15,665.42	-	128.91
Russia	37,358.77	1,029.28	159.57	-	8.70
Taiwan	45,593.72	995.11	6,145.74	-	111.69

Note: ICT totals correspond to the operational definition of ICT sector.
Value added: 2011 for Canada. Employment: 2011 for India. R&D personnel and BERD: 2011 for Brazil. Data are not available for R&D personnel for the United States (data are not homogeneous).
Source: Eurostat, elaborated by Ivie and JRC-IPTS.

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List of abbreviations used

BERD:	Business Expenditure on Research and Development
BRDIS:	Business R&D and Innovation Survey
DG CONNECT:	Directorate General for Communications Networks, Content and Technology
EU:	European Union
EUR:	Euros
Eurostat:	*Statistical Office of the European Communities*
FTE:	Full-time equivalent
GBAORD:	Government Budget Appropriations or Outlays on Research and Development
GDP:	Gross domestic product
GERD:	Gross domestic Expenditure on Research and Development
ICT:	Information and Communication Technologies
ISIC:	International Standard Industry Classification
Ivie:	Valencian Institute of Economic Research
JRC-IPTS:	Institute for Prospective Technological Studies
MS:	Member State
NACE:	Nomenclature statistique des activités économiques dans la Communauté européenne
OECD:	Organisation for Economic Co-operation and Development
PPS:	Purchase Power Standard
PREDICT:	Prospective Insights on R&D in ICT
R&D:	Research and Development
SIRD:	Survey of Industrial Research and Development
SNA:	System of National Accounts
US:	United States
VA:	Value added

List of definitions

BERD: Intramural expenditures on R&D performed within business enterprise sector during a specific period, whatever the source of funds (Frascati Manual).

BERD intensity: BERD/GDP.

Business R&D personnel: All persons employed directly in R&D by business enterprise sector, as well as those providing direct services such as R&D managers, administrators and clerical staff. Those providing indirect services, such as canteen and security staff, should be excluded (Frascati Manual).

Business R&D researchers: Business enterprise sector's professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned (Frascati Manual).

Full-time equivalent (FTE): A full-time equivalent corresponds to one year's work by one person. Consequently, someone who normally spends 40% of his or her time on R&D and the rest on other activities (e.g. teaching, university administration or counselling) should be counted as only 0.4 FTE.

Employment: Number of persons employed. In the SNA this is defined as all persons, both employees and self-employed, engaged in some productive activity that falls within the production boundary of the SNA and that is undertaken by a resident institutional unit.

GBAORD: Government Budget Appropriations or Outlays on Research and Development are a way of measuring government support for research and development activities. GBAORD include all appropriations (government spending) given to R&D in central (or federal) government budgets. Provincial (or State) government posts are only included if the contribution is significant. Local government funds are excluded.

GDP: Measures the total final market value of all goods and services produced within a country during a given period. GDP is the most frequently used indicator of economic activity and is most often measured on an annual or quarterly basis to gauge the growth of a country's economy between one period and another.

GERD: Gross domestic expenditure on research and development (GERD) is total intramural expenditure on research and development performed on the national territory during a given period.

GDP deflator: Implicit price deflator for GDP is calculated as GDP at current prices divided by GDP at "constant prices" (chained volume estimates or fixed-base volume estimates, depending on countries).

ICT BERD intensity: ICT BERD/ICT VA.

ICT manufacturing industries: Manufacture of electronic components and boards (NACE 261), Manufacture of computers and peripheral equipment (NACE 262), Manufacture of communication equipment (NACE 263), Manufacture of consumer electronics (NACE 264), Manufacture of magnetic and optical media (NACE 268).

ICT sector comprehensive definition: this definition is available mainly for EU Member States for the period 2008-2010. It corresponds to the definition given by the OECD in 2007. This definition includes ICT manufacturing industries, ICT trade industries and ICT services industries. Data in accordance with this classification are not available for some non-EU countries. See OECD definition: http://www.oecd.org/science/sci-tech/38217340.pdf.

ICT sector employment: all employed people in the ICT sector definition given by the OECD in 2007.

ICT sector operational definition: this definition allows for an international comparison with non-EU countries over a longer period of time (2006–2012), as some of these countries do not have the necessary disaggregated information to estimate all the ICT sub-sectors included in the comprehensive definition. This definition takes into account the standard distinction between manufacturing and services, but does not include the following sectors: Manufacture of magnetic and optical media (268) and ICT trade industries (465). In addition, ICT services industries are only available for two sub-sectors: Telecommunication (61) and the aggregate Computer and related activities (5820, 62, 631, 951). See Technical report: http://ftp.jrc.es/EURdoc/JRC77364.pdf.

ICT services industries: Software publishing (NACE 5820), Telecommunications (NACE 61), Computer programming, consultancy and related activities (NACE 62), Data processing, hosting and related activities; web portals (NACE 631), Repair of computers and communications equipment (951).

ICT trade industries: Wholesale of computers, computer peripheral equipment and software (NACE 4651), Wholesale of electronic and telecommunications equipment and parts (NACE 4652).

ICT total services: ICT trade industries and ICT services industries.

Labour productivity: Is defined as value added per unit of labour input (persons employed).

Member States: Member States of the European Union up to 2012: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

New Member States: 2004 and 2007 European Union Eastern enlargements consisting of Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia.

Other economies: countries included for the non-European comparison using the ICT sector operational definition (see definition above), consisting of: Australia, Canada, China, Brazil, India, Japan, Korea, Norway, Russia, Switzerland, Taiwan, United States.

Purchasing Power Standard (PPS): The artificial currency unit in which the PPPs and real expenditures for the European Union are expressed – namely, euros at average EU price levels. Euros at average EU price levels are euros that have the same purchasing power over the whole of the European Union. Their purchasing power is a weighted average of the purchasing power of the national currencies of EU Member States. As such they reflect the average price level in the

European Union or, more precisely, the weighted average of the price levels of EU Member States. PPS are defined by equating the total real expenditure of the European Union on a specific basic heading, aggregation level or analytical category to the total nominal expenditure of the European Union on the same basic heading, aggregation level or analytical category.

Value added: In the SNA it is defined as the value of output less the value of intermediate consumption; it is a measure of the contribution to GDP made by an individual producer, industry or sector.

European Commission
EUR 27510 EN – Joint Research Centre – Institute for Prospective Technological Studies

Title: THE 2015 PREDICT REPORT. An Analysis of ICT R&D in the EU and Beyond

Authors: Matilde Mas and Juan Fernández de Guevara Radoselovics

Luxembourg: Publications Office of the European Union
2015 – 90 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1831-9424 (online)
ISBN 978-92-79-52698-5 (PDF)
doi:10.2791/350598

LF-NA-27510-EN-N

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doi:10.2791/350598

ISBN 978-92-79-52698-5

Publications Office